TRANSACTIONS

OF

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS

VOL. XX

TWENTIETH ANNUAL MEETING
NEW YORK, JANUARY 20-22, 1914

SUMMER MEETING
CLEVELAND, OHIO, JULY 9-11, 1914

PUBLISHED BY THE SOCIETY
AT THE OFFICE OF THE SECRETARY
NEW YORK CITY

The Schoen Printing Co., 13-15 Vandewater Street, N. Y.

OFFICERS, 1914

President

SAMUEL R. LEWIS
Chicago, Ill.

First Vice-President

E. F. CAPRON
Chicago, Ill.

Second Vice-President

D. D. KIMBALL
New York City

Secretary

J. J. BLACKMORE
29 West 39th Street, New York City

Treasurer

J. A. DONNELLY
New York City

Council

SAMUEL R. LEWIS (*Chairman*)
E. F. CAPRON (*Vice-Chairman*)

D. D. KIMBALL	F. T. CHAPMAN
J. A. DONNELLY	J. M. STANNARD
J. F. HALE	F. G. McCANN
J. R. ALLEN	F. I. COOPER
W. W. MACON	H. M. HART

J. J. BLACKMORE (*Secretary*)

COMMITTEES, 1914

On Compulsory Legislation

J. D. HOFFMAN (*Chairman*)

DR. E. V. HILL F. T. CHAPMAN

On Tests

F. I. COOPER (*Chairman*)

L. A. HARDING J. A. DONNELLY

On Standards

Special Committee to Recommend a Standard Method for Testing Air Washers

A. E. STACEY (*Chairman*)

E. V. HILL H. M. HART

Special Committee to Recommend a Standard Method for Testing Radiators

JOHN R. ALLEN (*Chairman*)

L. C. SOULE C. W. JOHNSON

Special Committee to Determine the Most Effective Place for a Radiator in a Room

W. F. VERNER (*Chairman*)

J. R. ALLEN RALPH COLLAMORE

Special Committee to Show Latest Developments and Progress in Heating and Ventilating Industrial Buildings

Chicago Practice

E. L. HOGAN (*Chairman*)

J. H. KASSA C. C. CHEYNEY

New York Practice

J. I. LYLE (*Chairman*)

C. G. ARMSTRONG W. S. TIMMIS

Entertainment Committee

G. G. SCHMIDT (*Chairman*)

C. E. SCOTT PERRY WEST
C. A. FULLER W. H. DRISCOLL
HOMER ADDANS A. S. ARMAGNAC
F. G. McCANN CONWAY KIEWITZ
W. F. GOODNOW

CONTENTS

CCCXXX

THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

TWENTIETH ANNUAL MEETING

New York City, January 20, 21 and 22, 1914.

PROCEEDINGS.

First Day—Afternoon Session

Tuesday, January 20, 1914.

Meeting called to order at 2:45 p. m. by President Hale, a quorum being present.

On motion the calling of the roll and the reading of the minutes were dispensed with.

President John F. Hale then addressed the meeting as follows:

The meeting of the Council took place immediately after the last annual meeting and we organized in accordance with the regular practice. Since that time we have had seven council meetings at which the representatives were present—most of them who are in the East. We had communications from the various Western members so that we kept in touch with the entire situation and we believe that we have accomplished something this year. Committees were appointed in accordance with the usual practice and notifications given the different members. Unfortunately, some of the committees have not given their attention to the work as they might, which has been true of

committees for the last three or four years. It is to be hoped that the members of committees appointed hereafter will give more direct attention to the work because the reports to be made by them are of great interest and lead up to some final issue which so far we have not been able to accomplish in some cases.

The Council appointed, according to the Constitution and By-Laws, Mr. E. A. Scott as secretary and we are pleased to state that his work has been so good and he has accomplished so much that we hope the incoming administration will consider him favorably for the position again. It is an appointive position.

As you know, a special meeting was called for September 29th in order to revise the charter. That was done for the reason that the Constitution and By-Laws as amended and approved of several years ago, did not take into cognizance the fact that the charter under which we operated laid down certain rules and stipulations, and in order to bring about harmony between the two it was found necessary to hold a meeting for that purpose and the explanation will be given to you in the report of the Council.

We have taken in a great many new members this year. We have found it necessary to eliminate some members due to the fact that they have not paid their obligations. The report of the secretary will also cover that.

There has come to my mind the advisability of a committee for a symposium to be prepared under the Council of next year in which the manufacturer, the contractor, the architect and the engineer each have an opportunity to set forth their position so as to bring about a better understanding of the position of each, and I would recommend to the Council or the incoming President that such a committee be appointed or that such steps be taken to bring about a report of that kind.

There have been many things done this year which it is unnecessary for the chair to mention because they are covered in the other reports.

Incidentally, however, I wish to thank the members of the Council for their co-operation and especially the Secretary for the very excellent work that he has done particularly in the line of bringing about the collection of past dues which have held over so for a number of years and which have been rather a trial; and by constant work he has succeeded in accomplishing something which has never been accomplished before.

With your permission we will ask the Secretary to make his report.

REPORT OF THE SECRETARY

Your Secretary for the Society year ending January 22, 1914, begs to submit the following report:

The work of the Secretary's office during the past year has included the production of the transactions of the Society for 1912 in Volume 18. This volume, it might be stated in passing, is larger than any preceding one issued by the Society, comprising some 512 pages. It was delivered from the bindery two weeks ago and would have been in the hands of the members at this time had it not been for the extra work in the Secretary's office incident to this meeting. However, the books are all wrapped for shipment and will go forward on Friday or Saturday of this week. The final delivery of this book was delayed by several unavoidable circumstances. It was also hoped to have the volume for 1913 well under way by this time, but failure on the part of several members to return the discussion sent to them for correction prevented progress on this book. However, practically all the discussion has been returned and the manuscript is now ready for the editor.

As the ending of the financial year of the Society was changed, as the result of a resolution adopted at the last annual meeting, there is incorporated in this report the cost per member for administering the Society's affairs from January 23, 1913, to December 31, 1913. The figures for 1913 as given in the accompanying table of outgo since 1907 include all disbursements made by the present administration up to December 31, 1913. A review of the accounts shows that these amounts include all expenses in connection with the 1913 annual meeting and all expenses in connection with the Secretary's office, including supplies, postage, salaries, rent and the like for twelve months, as bills for January, 1913, were not paid until after January 23, last year. They also include the printer's final bill on the production of the 1911 volume as well as the cost of distributing that volume to the members. In other words, the figures for 1913 as given in the accompanying schedule include practically the administrative expenses of the Society for one year, as the only accounts payable unsettled on December 31 and not included in the accompanying table aggregate only $8.75. There was no

Year Book issued in 1913, which meant the saving of about $150. This shows that the outgo per member is slightly below the annual dues. However, it may be expected that the administrative expenses for 1914 will be somewhat higher, as the cost of producing the 1912 volume will be several hundred dollars in excess of the 1911 volume.

PER CAPITA EXPENSE FOR SEVEN YEARS

Year	Mean Number of Members	Total Expenses	Expense per Member
1907	301	$3,662.45	$12.20
1908	335	4,025.84	12.00
1909	357	4,687.41	13.13
1910	377	4,269.83	11.36
1911	405	4,793.08	11.83
1912	437	5,013.19	11.47
1913 (Jan. 23-Dec. 31, 1913)	455	4,400.90	9.67

A keen interest has been taken by the members quite generally in matters having to do with the Society's work and welfare. Members have been prompt in responding to the ballots and requests for information which were sent out during the year, and notably so in the case of the questions on the Model Ventilation Law.

The Secretary wishes to express his appreciation of the prompt responses of many of the members in the effort made to get the financial affairs of the Society in the best possible shape during the year. The statements accompanying the report of the Council will show $1,245 in initiation fees and dues outstanding on December 31, 1913. Since that time the names of 18 members who were in arrears for dues for two years have been removed from the rolls by the Secretary acting under instructions of the Council. This means that $360 has been charged off from the dues account in addition to the amounts shown on the statements. The collections since January 1 have totalled $180 for initiation fees and dues. Deducting the amount written off and the collections from the initiation fees and dues account, reduces the amount outstanding at this time to $705. This represents $215 initiation fees and dues of 11 candidates elected December 19, who have not yet qualified; dues of one member owing $30.00 who has promised to have check in the hands of the Secretary prior to the adjournment of this meeting and 46 members who still owe for 1913 dues. In other words, there is only one

member now on the rolls who owes for dues prior to 1913 and dues and fees outstanding have been reduced within the year from practically $1,800 to $705.

The Secretary wishes at this time to express his appreciation to the members who assisted so materially in the preparation and program for both the semi-annual meeting at Buffalo and this meeting also.

Respectfully submitted,

EDWIN A. SCOTT, Secretary.

The Secretary's report was on motion ordered to be entered in the transactions of the Society.

President Hale: The Treasurer's report is the next one to be presented.

Mr. Donnelly: The Treasurer's report as to receipts and disbursements is the same as the Secretary's, hence no Treasurer's report is necessary and none will be presented.

The Treasurer's balance on hand, however, is not the same as that of the Secretary, for the reason that the Secretary entered some money as being on hand on December 31, that was not turned over to the Treasurer until after that date.

I notice under total statement of income and outgo that it will be necessary for the Secretary and Treasurer to get together a little bit. I would like the Secretary's report and the Treasurer's report to agree in the total receipts and the total expenditures and frankly I did not get time to make up the report right after the first of the year and the books have been in the office at the disposal of the auditing committee the last week and I had not seen the Secretary's report.

Some remarks were made by members as to the per capita cost, after which the report of the Council was read.

Secretary Scott read the Council report and stated: Everything has been read with the exception of the membership status which is self-explanatory. Five hundred and fifty dollars was the total write-off for 1913. By removing the names of members on January 1st who owed for two years it prevents any further write-off for failure to pay dues for 1914. There were 18 removed in 1913. I think everything else is plain on the statement.

REPORT OF THE COUNCIL

The Council makes the following report of its administration of the affairs of the Society since it was organized on January 23, 1913, immediately following the last annual meeting.

The Council has maintained headquarters in the Engineering Societies' Building, 29 West Thirty-ninth Street, New York City, and the office of the Secretary has been used quite frequently throughout the year by individual members and by committees for meetings. The Council and Executive Committee have held 10 meetings during the year, all of which have been well attended and several members who could not attend certain meetings contributed their views in writing in advance on subjects to be considered at those particular meetings.

The Summer meeting of the Society was held at Buffalo, on July 17, 18 and 19 and was notable in that the attendance was greater than at any previous meeting. A valuable opportunity was also afforded the members at that meeting to witness several tests of heating equipment conducted at the Institute of Thermal Research. It is unnecessary to deal at length with these tests in this report, as special committees have prepared reports which will be read at this meeting.

A meeting of the members of the Society was held in the Engineering Societies' Building, on September 29, to consider amending the charter so as to increase the number of Directors to 12, so as to agree with the constitution, and to receive amendments to the constitution. At that meeting the members took the necessary steps to amend the charter so that it might designate 12 as the number of Directors on the Board. The amendments to the constitution proposed at that meeting were submitted to the membership for a mail vote. The ballots were canvassed January 19 and all the amendments as proposed have been accepted and the constitution is therefore revised as follows:

ARTICLE II

MEETINGS

Section 1.—All business meetings of this Society shall be held in New York City. The annual meeting shall begin on the third Tuesday in January of each year, and continue from day to day as the Directors may arrange. Special meetings may be called

at any time at the discretion of the Directors, or shall be called upon the written request of twenty (20) members.

Section 2.—Professional sessions for the reading and discussion of papers, reports of committees, etc., shall be held at least twice a year. The time and places of holding such sessions shall be determined by the Directors at least sixty (60) days prior to the dates selected.

Section 3.—Fifteen members present (either in person or by proxy) shall constitute a quorum.

NOTE: Wherever "Council" appears change to "Directors."

ARTICLE IV

ELECTION OF MEMBERS

Section 2.—Honorary members shall be proposed only at annual meetings, and all proposals must have the unanimous endorsement of the Board of Directors before their names are submitted to the meeting for election.

Section 4.—Any member entitled to vote will indicate the nature of his vote, whether affirmative or negative by writing the word "Yes" or "No" opposite the name at the point to be provided in the ballot. Each member shall draw a line through the name or names of any or all candidates for whom he does not desire, or does not feel qualified by sufficient acquaintance, to vote. The ballot is to be enclosed in two envelopes, the inner one to be blank and the outer one endorsed by the member voting, and returned to the office of the Society within thirty (30) days of its date.

ARTICLE VI

Section 1.—The affairs of the Society shall be managed by a Board of Directors of twelve members, which shall consist of the President of the Society, two Vice-Presidents, eight members and a Treasurer. Four members shall constitute a quorum for the transaction of business. The Secretary may take part in the deliberations of the Board of Directors, but shall not have a vote therein.

Section 4.—Strike out the words "and shall send a copy thereof annually to each member."

Section 6.—The Board of Directors may appoint a suitable member of the bar as counsel to the Society during its term of

office to perform such duties as may be assigned to him. He shall become an associate member.

Section 7.—Insert "The Board of Directors shall present at the annual meeting a report, verified by the President and Treasurer or by a majority of the Directors, showing the whole amount of real or personal property owned by it, where located and where and how invested, the amount and nature of the property acquired during the year immediately preceding the date of the report, and the manner of the acquisition, the amount applied, appropriated, or expended during the year immediately preceding such date, and the purposes, objects or persons to or for whom such applications, appropriations or expenditures had been made, and the names and places of residence of the persons who have been admitted to membership in the corporation during such year, which report shall be filed with the records of the corporation and an abstract thereof entered in the minutes of the proceedings of the annual meeting. It shall fill any vacancies occurring in the Board of Directors and shall file a certified copy of such appointment with the clerk of the county of New York."

ARTICLE VII

Section 1.—Insert: "Two Vice-Presidents to hold office for one year."

"Eight Directors, each to hold office for one year."

Change last paragraph to read "A President or Vice-President shall not be eligible, etc."

Section 2.—Change "sixty" to "ninety" in the ninth line.

Section 4.—Each member entitled to vote shall cancel the names of all candidates for whom he does not intend to vote, and return his vote, so that it will reach the Secretary before the date of the annual meeting, with a duly authorized proxy directing the Secretary to cast his ballot. Any member may write, etc.

It is gratifying to be able to present such a favorable financial statement as is to be found in the accompanying tabulation of income and outgo for the year ending December 31, 1913. The balance on January 21, 1913, of $1,041.62 has been increased to $2,823.20 on December 31, 1913, with all bills with the exception of $8.25 paid. This increased balance is the direct result of a policy instituted during the year of not carrying members in arrears for dues on the rolls beyond a reasonable time. During the year a mail ballot was taken to obtain the views of members

on the desirability of carrying the names of members on the rolls who are in arrears for more than two years. The vote was overwhelmingly in favor of dropping all members on January 1 of each year who owe for the two preceding years. The Council considered the vote mandatory and accordingly instructed the Secretary to remove from the rolls on January 1 of this year all names of members in arrears for two years. This removed from the roll 18 names and reduced the dues and fees outstanding to $885 and left, with one exception, only the names of members on the roll who owed for 1913 dues. The Society is therefore not only in a better financial position than for some years, but the dues and fees accounts are also in better shape.

STATEMENT OF INCOME AND OUTGO

Cash on hand, January 21, 1913				$1,041.62
Receipts				
Dues			$4,988.00	
Initiation Fees			745.00	
Sale of Transactions, net:				
Vol. 1	$17.50			
" 2	17.50			
" 3	17.50			
" 4	17.50			
" 5	17.50			
" 6	17.50			
" 7	17.50			
" 8	17.50			
" 9	30.00			
" 10	22.50			
" 11	30.00			
" 12	30.00			
" 13	22.50			
" 14	22.50			
" 15	30.00			
" 16	22.50			
" 17	107.50			
" 20	7.50			
Acct. of complete set	20.00			
		$485.00		
Less express		1.15		
			483.85	
Pin Badges:				
Solid gold	$42.25			
Plated	16.25			
			58.50	
Sale of year book			6.00	
Interest on deposits			32.29	
				$6,313.64
				$7,355.26
Disbursements				
Transactions:				
Vol. 17, printing			$971.79	
Vol. 18, editing		$125.00		
Extra cuts		24.97		
			149.97	
Vol. 19, engravings		$163.71		
Electros sold ($52.55—$17.10)		35.45		
			128.26	

Pin Badges:			
Solid gold	$30.00		
Plated	17.25		
		47.25	
Meetings expense:			
Advance papers:	$390.15		
Sale of	89.06		
		301.09	
Stenographer		287.40	
Meeting rooms, printing, etc.		296.25	
Postage, expressage, etc.		386.62	
General administration:			
Salaries		1,188.00	
Assessments (rent) for office		396.00	
Office stationery and supplies		139.53	
New furniture		1.01	
Storage		28.40	
General printing		38.75	
Ballots		102.50	
Telephone		40.75	
Committees		21.50	
Exchange		6.99	
Total			$4,532.06
Cash on hand			2,823.20
			$7,355.26

A statement of the assets and liabilities of the Society is given hereinafter. It is interesting to note that the quick assets of the Society are in excess of its entire obligations and that the affairs of the Society have been so conducted since its organization that the equity of each member is in excess of his original initiation fee. In other words, on the basis of 462 members the equity per member on December 31, 1913 was $18.46. The statement of assets and liabilities are shown in an accompanying table.

The Society has been represented at other meetings during the year as follows: At the Fourth International Congress on School Hygiene held in Buffalo, by a Committee comprising Frank Irving Cooper, Chairman, D. D. Kimball, C. B. J. Snyder, S. R. Lewis and N. L. Patterson. At the International Conservation Congress by a Committee comprising Henry Adams, Chairman, M. S. Cooley, and the Society also has a special committee to confer with the National District Heating Association comprising E. F. Capron, Chairman, M. L. Foote, W. C. Green, L. C. Soule and J. M. Stannard.

A further donation has been made to the Society by Dr. Wm. Paul Gerhard, C. E., comprising some fourteen books and pamphlets on heating and ventilation in the English and German languages as per the list given hereinafter. These volumes now form a part of the Society's library and it is desired that the Society, at its annual meeting, take special recognition of the

bequest which enhances the value of the donation made by Dr. Gerhard one year ago. The list follows:

Ventilation and Warming of Buildings, by Isaac D. Smead.

Der gegenwärtig Stand der Heizfrage, von E. Sturm.

Heating and Ventilating Schools, by John J. Hogan.

Warming, Ventilating and Sanitary Appliances for Public Schools, by the J. L. Mott Iron Works.

Circulation at the American Institute Fair, by Model Heating Co.

A Circular on the Warming and Ventilation of School Houses and Churches, by the Mahony Combination System.

Die Heizungs- und Lüftungs-Einrichtungen des Eisenwerks Kaiserslautern.

Die Heizungs und Lüftungs Systeme des Eisenwerks Kaiserslautern, two volumes.

Gesunde Luft in unseren Häusern, von Kauffer & Co.

Die Beheizung der Räume, von Kauffer & Co.

Supplement 2, Gesunde Luft in unseren Häusern, von Kauffer & Co.

Centralheizung und Ventilation, by J. L. Bacon.

Patent Central-Heizung mit Ventilation System, by Bechem & Post.

ASSETS

Furniture and fixtures			$200.00
Cuts used in printing volumes			200.00
Stationery and supplies			25.00
Proceedings			
Vol. 1	137		
Vol. 2	13		
Vol. 3	107		
Vol. 4	127		
Vol. 5	99		
Vol. 6	120		
Vol. 7	109		
Vol. 8	87		
Vol. 9	141		
Vol. 10	131		
Vol. 11	146		
Vol. 12	131		
Vol. 13	138		
Vol. 14	141		
Vol. 15	166		
Vol. 16	162		
Vol. 17	192		
	2,147	at $3.00	6,441.00
Accounts receivable			24.60
Library			400.00
Membership dues outstanding		$1,010.00	
Less uncollectable (estimated)		110.00	
			900.00

Initiation fees outstanding	235.00	
Badges, Registration	15.00	
Badges, Pin	15.00	
Cash on hand	2,823.20	
		$11,278.80

LIABILITIES

Estimate Cost of Volumes to be issued to members:		
Vol. 18	$1,500.00	
Vol. 19	1,200.00	
Membership dues prepaid	40.50	
Accounts payable:		
Storage Bill	7.50	
Telephone	1.25	
		2,749.25
Membership equity		8,529.55
		$11,278.80

The details in the changes of membership are shown in the accompanying table. Two ballots were canvassed in the usual manner, one on June 19 and another on December 19, adding 27 and 30 members respectively to the rolls. This increase in membership, however, has been largely offset by losses from various causes, especially through the dropping of members in arrears for dues. Two candidates reported one year ago as being elected on the ballot of December 19, 1912, failed to qualify.

The membership has increased by 13 during the year and now numbers 462.

The Society suffered the loss of four members by death during the year. The llst includes a past-president who was also a charter member; an honorary member, and two other charter members. Wiltsie F. Wolfe, who was President of the Society for the year 1898-1899, passed away on December 4. Dr. J. S. Billings, an honorary member of the Society, died on March 10, John A. Payne, on March 3, and R. C. Clarkson during the latter part of December.

STATUS OF MEMBERSHIP

Honorary members:				
Total number, January 21, 1913	3			
Loss by death	1			
Total number, January 20, 1914				2
Members:				
Total number, January 21, 1913			390	
Accessions by election	45			
by reinstatement	1			
by advancement from associate	1			
by advancement from junior	1			
		48		
Losses by resignation	6			
*by non-payment of dues	27			
by death	3			
		36		
Net increase			12	
Total number, January 20, 1914				402
Associate members:				
Total number, January 21, 1913			38	
Accessions by election		8		
Losses by non-payment of dues	2			
by failure to qualify	1			
by advancement to member	1			
		4		
Net increase			4	
Total number, January 20, 1914				42
Junior members:				
Total number, January 21, 1913			18	
Accession by election		4		
Loss by advancement to member	1			
†by non-payment of dues	4			
by failure to qualify	1			
		6		
Net loss			2	
Total number, January 20, 1914				16
Total membership January 20, 1914				462
Total membership January 21, 1913				449
Total net increase				13

STATUS OF DUES ACCOUNT

Cr.			
In arrears, including portion of dues of candidates elected December, 1912	$1,635.00		
Paying members, January 21, 1913—443 at $10	4,430.00		
Class of candidates, June 19—27 at $10	270.00		
Class of candidates, December 19—30 at $5	150.00		
Reinstated members, back dues	40.00		
		$6,525.00	
Dr.			
Prepayment dues 1913 account in 1912	$12.00		
Written off by death and resignation	40.00		
Written off by non-payment of dues	500.00		
Written off by failure to qualify	10.00		
Total dues received	4,993.50		
		$5,555.50	
Dues outstanding			$969.50

* Includes 17 members removed from rolls on January 1, 1914, in arrears for dues for two years, making $340 charged off against 1914 Dues Account.

† Includes 1 member removed from rolls on January 1, in arrears for dues, making $20 charged off against 1914 Dues Account.

STATUS OF INITIATION FEES ACCOUNT

Cr.			
In arrears, including portion of candidates elected December, 1912	$165.00		
Class of candidates, June 1	405.00		
Class of candidates, December 19	430.00		
Fee of advancement from junior grade	5.00		
		$1,005.00	
Dr.			
Total initiation fees received	$745.00		
Written off by failure to qualify	25.00		
		770.00	
Fees outstanding			235.00
			$1,204.50
Recapitulation			
Total debit accounts of members			$1,245.00
Total credit accounts of members			40.50
			$1,204.50

The Council took steps to convey the condolence of the Society to the families of the bereaved in each case and a Special Committee comprising three past-presidents of the Society, namely, Prof. Wm. Kent, Mr. C. B. J. Snyder, and Mr. R. P. Bolton was appointed to attend the memorial service to Dr. Billings, held at the New York Public Library.

Those who were honorably withdrawn from membership because their resignations could be accepted were: A. W. Varney, Detroit, Mich., L. G. McCrum, Somerset, Pa., R. O. Hargreaves, Detroit, Mich., John Trainor, Baltimore, Md., A. W. Glessner, Chicago, Ill., and C. M. Slotboom, The Hague.

JNO. F. HALE, Chairman.

Chairman Hale: You have heard the report of the Council, what is your wish in connection with it?

Some discussion obtained in regard to the report and some criticism was made that valuing the volumes at $3 each was more than they were worth as stock material and the chances were that the Society would not realize a sum equal to that in the sale of the volumes.

Considerable discussion obtained at this point of the proceedings in regard to the question of when the dues of the members became payable.

It being the general opinion that members were not in arrears until after the annual meeting.

The Secretary explained that the changes recommended by the Council provided that the fiscal year should end on December 31 and that all members' dues were payable on January 2, in advance.

Chairman Hale: It is the ruling that a member in arrears for 1913 dues only may vote at this meeting. With your permission we shall now go on to the next on the program for this session, which is a report from the Illinois Chapter of the Society. Is there someone here who represents the Illinois Chapter; Mr. Hart, I believe.

Mr. Hart: (Reads the Report of the Board of Governors of the Illinois Chapter).

REPORT OF THE ILLINOIS CHAPTER

Since our report at the July semi-annual meeting, the Illinois Chapter has elected new officers, as follows:

President, H. M. Hart.

Vice-President, C. F. Newport.

Secretary, Will L. Bronaugh.

Treasurer, August Kehm.

The Board of Governors, in order to create more interest on the part of individual members, adopted a plan of debating on the relative merits of competitive methods at the monthly meetings. As an illustration, the topic of the November meeting was a debate on the relative merits of "Upward Method of Ventilation vs. Downward Method of Ventilation."

At the December meeting we considered the relative merits of "Forced Circulation of Hot Water vs. Direct Steam Vacuum Heating for Industrial Plants."

The January meeting was assigned to the consideration of the merits of "Hot Blast vs. Direct Steam Heating for Factory Purposes."

Our February meeting is assigned to the "Chicago Ventilation Commission" and consideration of the progress they have made. This Commission, at the present time, is conducting some tests as to the amount of ventilation required for theatres, and they have constructed a cabinet for the purpose of an investigation of what effect the lack of ventilation produces on an individual. These tests are now under way and it is hoped that

shortly some valuable information can be distributed. The March meeting will be devoted to a consideration of the relative merits of "Hot Water vs. Modulated Steam for Residence Heating."

Air Conditioning will be the topic at the April meeting, and while the May meeting has not been assigned, it seems that at the present time, this will be devoted to a consideration of "Chimney Drafts," including a presentation of all the data procurable. It is hoped that this paper will be the nucleus of a paper for the parent body. In a small way, we have started the "Question Box" idea and so far it has brought forth some desirable information.

The Chapter has been fortunate in being able to lend some assistance in the field of compulsory ventilation, in that, acting on the Chapter's recommendation, the Chicago City Council refused to rescind the ventilation ordinances applying to theatres. That the City Council took this action is due entirely to the efforts of the Illinois Chapter. Various and sundry members of the Chapter are now devoting their time and giving assistance to the Department of Health in the prosecution of non-ventilated picture theatres.

We should like to emphasize the point brought out at the semi-annual meeting in Buffalo, that the Society should be very careful of its papers, as the Society records were used by the objectors to this ordinance.

The Illinois Chapter is contributing financially to the Chicago Ventilation Commission, and three of its members still retain membership in it, and we are sure that this Commission is going to accomplish a great deal of good.

Financially, we are in excellent shape, and have been able to cut our dues from $10.00 per year to $5.00.

We have added four new members, and have sent in a number of applications to the parent body for membership.

Respectfully submitted,

WILL L. BRONAUGH, Secretary.

Mr. Hart: I may add that the method in conducting meetings, using this debate idea, has met with considerable interest among the members and resulting in an increase of attendance of about thirty per cent. over previous years and brings out some very interesting discussions. The method of the meetings

is to appoint a committee of three members to write papers on each side of the question and each member of the committee is supposed to present a paper covering the side he represents, after which the entire membership is invited to take part in the discussion, each member being called upon and asked to respond for one side or the other. No decisions are given in favor of either side and we don't try to legislate in favor of one method of heating over another but we are trying to get some information that will result in benefit to everybody.

Chairman Hale: You have heard the report of the Illinois Chapter. What is your wish in connection with it? With your permission it will be received and placed on file.

In the absence of Mr. Goodnow, Secretary Scott will read the report of the New York Chapter.

REPORT OF THE NEW YORK CHAPTER

The Secretary of the New York Chapter desires to report that the Chapter is in a very good condition—financially—and while the membership does not show any increase, it is practically the same as a year ago, totalling 74 members, consisting of 1 honorary member, 65 members, 6 associates and 2 juniors.

The Chapter has held its regular monthly meetings in the past year, which have been uniformly well attended. The annual dinner was held in May at the Engineers' Club, New York and there were 143 members and guests present.

The annual meeting of 1913 was held in October at which the following officers for the year 1913-1914 were elected and installed:

President, D. D. Kimball.

Vice-President, J. I. Lyle.

Secretary, W. F. Goodnow.

Treasurer, Arthur Ritter.

Board of Governors, Frank G. McCann, Walter S. Timmis, William H. Driscoll.

Various committee reports were also received at this meeting.

The November meeting was devoted to a discussion on "Vacuum vs. Vapor and Low Pressure System for Heating."

At the December meeting "Control of Atmospheric Conditions in Printing Establishments," was the topic for discussion and was presented by Mr. Walter S. Timmis.

At this meeting several amendments to the Constitution were adopted.

Owing to the Society's annual meeting taking place in January, the January 1914 meeting of the Chapter is merged with the Society meeting.

It is proposed to discuss at the meetings for the remainder of the Chapter year the following:

February—"Fan Selection."

March—"Schoolhouse Heating and Ventilation."

April—"Hot Water Heating."

Respectfully,

WALLACE F. GOODNOW, Secretary.

Chairman Hale: You have heard the report of the New York Chapter. With your permission it will be received and placed on file.

REPORT OF THE MASSACHUSETTS CHAPTER.

The Massachusetts Chapter is glad to report a very successful season's work. A meeting was held each month from October to May, inclusive, and each month a special speaker was secured which added greatly to the interest and benefit.

The Chapter has been active in securing a revisal of the Massachusetts laws dealing with the heating and ventilating of buildings used for public purposes. The new law has been signed by the Governor and took effect November 1st, 1913. However, the Chapter does not indorse the interpretation of this law as made by the Massachusetts District Police Inspection Department as to the ventilation of theatres, halls and places of public gathering, because the law states that "the ventilation in all cases shall be taken off from near the floor level."

The new laws and regulations are issued in booklet form and can be obtained upon application. The new regulations dealing with school house construction have yet to be issued, but it is understood that they are on the press. A new state law has also been passed and signed dealing with Moving Picture booths.

The Chapter has also been active in securing new members for the parent body and no less than eight persons accepted for

membership having been nominated by this Chapter, a total of over fifty per cent. of the Chapter's own enrollment.

The first school in the world for Public Health Officials has been opened by Harvard College this winter under the direction of Dr. Milton J. Rosenau.

Our President, Mr. F. I. Cooper, was appointed by the Governor to attend the International Congress of School Hygiene in Buffalo, N. Y., in August, which gives us recognition worthy of mention.

Officers, 1913-1914

J. W. H. Myrick, President.

Charles F. Eveleth, Vice-President.

F. I. Cooper, Secretary.

William T. Smallman, Treasurer.

Board of Governors—Albert B. Franklin, Charles Morrison, H. W. Whitten.

Respectfully submitted,

J. W. H. Myrick, Secretary.

Chairman Hale: You have heard the report of the Massachusetts Chapter. With your permission it will be received and placed on file.

The next report in order is that of the Committee on Standards.

First of these reports is regarding a code for testing House Heating Boilers.

Secretary Scott: That report has been printed and distributed to the members. There are some printed copies outside in case some of the members have not the pamphlet in this form. As I have trouble with my throat I will ask Mr. Chew to read the report.

The report was discussed by Mr. Chew, Wm. Kent, Mr. Hale, Mr. Mackay, Mr. Newport, Mr. Gombers, Mr. Donnelly, Mr. Davis, Mr. Barron, and Mr. Seward, and on motion was referred together with the discussion, to the committee for further report.

On being referred back to the committee they decided they could accomplish nothing more than given in the report.

The President with the advice of the Vice-President and Secretary decided to hold the matter in abeyance till the art had reached a higher state of development.

President Hale: The report of the Committee on Heating Guarantees will be made. Mr. Mackay is Chairman of that Committee.

Mr. Mackay: Your committee has nothing further to report than that which they reported two years ago in 1912 and with your permission I will read that report, or the guarantee part of it only. We felt that it was out of the province of the committee but rather that of the legal fraternity to formulate that into such shape that it could be put into a standard specification, and we would report that if the Society sees fit that counsel be employed to draft that in such shape as to present the views of the Society in legal form in specifications.

That's all, Mr. Chairman. We have not seen fit to increase that, and we recommend that the Society receive it and that it be framed up in legal form and added to heating specifications.

President Hale: That subject is open for your discussion. Are there any members who wish to make any remarks upon the subject? What is the wish of the members as to the advisability of hiring counsel for the purpose of whipping this into line? It has been moved and seconded that the recommendations made by the committee to the effect that counsel be retained for the purpose of preparing this guarantee in legal form be concurred in. All in favor say Aye. Carried.

With your permission I will deviate a little bit from the rules and from the order of business and will take this time to appoint Mr. A. A. Kieb, Mr. R. B. Hunt and Mr. F. K. Davis a committee of three to canvass the votes for officers to report this evening. We will bring up the subject of the Report by the Secretary of the meeting relative to the change in the constitution and by-laws.

Secretary Scott: I will start in connection with this matter by reading the notice that was sent out for the call of the special meeting.

Professor Kent: I would like to ask what authority the Council had to call a meeting.

Mr. Donnelly: I would like to call to your attention that we presented this matter at the summer meeting and received a vote at that time to call the meeting, the necessity for calling the special meeting was really for the amendment of the charter. The charter is not a part of the constitution, and the law states just how the charter can be amended. Professor Kent's point as to whether this was a regular meeting or a special meeting was covered recently very clearly in the impeachment of Gov-

ernor Sulzer; at a special meeting of the legislature the point was raised that it was a special and not a regular meeting and the attorney-general and the courts decided against the objection. We took that question up in the Board of Directors and considered that a good precedent to follow. That the special meeting of the Society was really a regular meeting; it was a regular meeting in that it was regularly called.

Chairman Hale: Mr. Donnelly was appointed by the Council, to investigate as a member of the Council, the question of the legality of our operating under certain provisions of the constitution and by-laws due to the fact that we were not in exact accordance with the law relative to the charter and the report made by the Council at the summer meeting was in accordance with the report of Mr. Donnelly. So Mr. Donnelly is more thoroughly acquainted with that than I am, and with your permission he will explain.

Mr. Donnelly: Just that point as to the necessity of holding a special meeting. In our constitution we stated that we would hold two meetings a year; the laws under which we were incorporated state that meetings of this membership corporation must be held in the city in which our principal office of business is located; that means that we cannot hold a meeting of the membership of this Society outside of New York City, no meetings of the corporation at all; that means that the meetings we have been holding in the summer have really been professional sessions for the discussion of papers and meetings in which no business having to do with the business of the Society could be transacted. Therefore, the new constitution calls the annual meeting a meeting and calls the other assemblages professional sessions for the discussion of papers. Of course in reality we cannot transact any business at either a special meeting or annual meeting, excepting the election of officers and the reception of reports of officers and board of directors. Now the fact that we could not hold a meeting and could not propose an amendment of the charter in Buffalo made it necessary to hold a meeting in New York City. I consulted a member of the bar and he stated that a recent opinion of the Attorney-General had held that there was no authority or law for holding a meeting outside of the city where the business office was and there was no possible way of holding such a meeting outside the state with the exception of membership corporation that runs over five

thousand membership and they elect delegates and hold meetings anywhere in the United States, the different associations being represented by them.

On motion the matter was laid on the table to be taken up the last session on Thursday.

Secretary Scott: One of the members brought up this afternoon a question regarding the statement of assets and liabilities as presented in the Council's report. Probably a word of explanation is necessary. We have something like 2,000 volumes of the proceedings on hand which were put in at $3 per unit. In arriving at that I took several things into consideration. First, the cost of publishing those volumes. Second, what it would cost to reproduce them and the rapidity with which those volumes of proceedings are moving. Last year we sold something like $400 worth of the proceedings, $483.85—almost $500 worth of the proceedings were sold last year.

President Hale: I have just received a report of the committee to count the votes cast for the nominating committee. They report as follows:

F. K. Chew	23
P. H. Seward	21
J. I. Lyle	20
C. F. Newport	17
J. D. Cassell	17

These gentlemen will therefore constitute the Nominating Committee for the purpose of recommending candidates for officers for 1915.

Considerable discussion obtained at this time in relation to changes in the constitution, but no action was taken at this session as it was thought best by the Chair to take it up at a later session under unfinished business.

It was then moved and seconded and voted that the session adjourn.

First Day—Second Session.

Tuesday, January 20, 1914

Meeting called to order by Vice-President Franklin, at 8:25.

Dr. E. Vernon Hill read a paper entitled, A Report on the Work of the Ventilating Division of Chicago Health Department.

It was discussed by Mr. A. B. Franklin, Prof. Wm. Kent, Mr. Davis and Dr. M. W. Franklin.

President Hale arrived at this time and took the Chair.

President Hale: The next on the program is a report from the tellers who canvassed the votes of the election. Mr. Kieb will report.

Mr. Kieb: Your committee begs to submit the following as the result of the canvass of the ballots for officers and managers of the American Society of Heating and Ventilating Engineers for 1914.

The Committee found that 139 ballots had been received. One member refusing to vote for anyone because of the fact that there was only one ticket in the field. One ballot was rejected by the Committee, it being marked in such a way as to be unintelligible. There are 137 ballots cast, making a total of 139. The following is the result:

For President.

Samuel R. Lewis 133

For Vice-President.

Edmund F. Capron 134
Dwight D. Kimball 121

For Treasurer.

James A. Donnelly 125

For Managers.

Samuel R. Lewis 131
Edmund F. Capron 132
D. D. Kimball 127
James A. Donnelly 125

John F. Hale	133
John R. Allen	128
W. W. Macon	131
Frank T. Chapman	137
James M. Stannard	135
Frank G. McCann	130
Frank Irving Cooper	132
H. M. Hart	130

President Hale: According to the vote of the Society Mr. Samuel R. Lewis is declared President for 1914; Mr. Edmund F. Capron is declared Vice-President; Mr. D. D. Kimball is Second Vice-President; Mr. James A. Donnelly, Treasurer, and the Managers: Messrs. Lewis, Capron, Kimball, Donnelly, Hale, Allen, Macon, Chapman, Stannard, McCann, Cooper and Hart.

Professor Kent raised the question as to the legality of the election.

President Hale replied that the question of legality of previous elections had been raised and the present election was held in accordance with the advice received from special counsel employed to look into and report on the question.

Chairman Hale called for the report of the Committee on a Model Compulsory Ventilation Law, Prof. J. D. Hoffman, Chairman.

In the absence of the Chairman of the Committee, the report was read by Mr. Frank K. Chew.

The Chairman explained that this was not a complete report but was one of progress only and was not yet in shape for publication.

It was discussed by Mr. Chew, Mr. Hale, Mr. Hart and Mr. Weinshank after which it was voted to bring it up again for discussion at the next session.

On motion duly put the meeting adjourned at 10:15 p. m.

SECOND DAY—SPECIAL SESSION

Wednesday Morning, January 21, 1914

Meeting called to order at 10:45 by President Hale.

President Hale: This is a special meeting that is not on the program, but which we considered advisable last evening because of the fact that there was not sufficient time to discuss the subject of the report from the Committee on Legislation for Compulsory Ventilation.

Mr. Weinshank, who is the Chairman of the Indiana Committee on Compulsory Legislation, has had some experience in connection with the enactment of a law in that state, and has handed in a minority report. We will ask him to take such points from his report that may differ from the main report, and not read it in its entirety. The thought is to get his impressions and then discuss as to what further should be done to have the committee make a definite and final draft of a law that can be sent out to the various states or to the members of the committees, so that it will assist them in putting before the legislatures of the different states a draft that would be satisfactory to the engineering societies or at least the American Society of Heating and Ventilating Engineers and be of assistance to them in getting something started in the right direction. We will ask Mr. Weinshank to make his remarks, not reading the entire report but touch the high points only.

After Mr. Weinshank had spoken the matter was discussed by Mr. Lewis, Mr. Hale, Mr. Cassell, Mr. Chew, Dr. Hill, Mr. Myrick, Mr. Hart, Mr. Chapman, Mr. Quay, Mr. McCann and Mr. Davis.

After the discussion, a motion was made that the Chair appoint a committee to take this report together with a copy of the discussions made at the meeting and from that and any other data that can be collected to present their views on the subject at a later session.

The Committee appointed by the Chair for the above purpose was Mr. Lewis, Dr. Hill, Mr. Busey, Mr. Cooper and Mr. Cassell.

Chairman Hale: Inasmuch as this is a special session, no more business will be taken up, but the Secretary desires me to announce the fact that the paper of W. F. Verner, The Flow of

Steam in Pipes, will not be received from the printer in time to present it at this afternoon's session, but that it will be presented at a later session.

The special meeting adjourned at 12:45.

Second Day—Afternoon Session

Wednesday, January 21, 1914

Meeting was called to order by President Hale at 2:30 o'clock.

President Hale: The meeting is called to order. We will open the meeting by the reading of the two papers by Mr. A. M. Feldman, who is present this afternoon, one entitled "Cooling Two Rooms in a Country Residence," the other "A Ward Cooling Plant in a Hospital," and if read together and discussed at the same time we will save time and gain by it. We will defer the reading of the first two papers on the program until afterward.

Mr. Feldman reads both papers. The papers were discussed by Dr. Levey, Mr. Hale, Prof. Winslow and Mr. Payson.

Chairman Hale: A portion of the work of the afternoon session yesterday, had to be passed on to a later session due to the fact that certain reports were not ready. The special committee of the Committee on Standards for the Standardization of the Use of the Pitot Tube, was appointed, and have met a number of times, first in Buffalo at the summer meeting, and they have met to-day also and are present, and Mr. Lyle, the chairman of that committee is ready to make his report.

Report read by Mr. Lyle.

The report was discussed by Dr. Hill, Mr. Busey and Mr. Verner, after which it was voted that the report be accepted and placed on file.

President Hale: The next paper is one by Professor Allen and in the absence of the author the Chair will ask Mr. Verner if he will read that paper to the members after which it will be discussed. The subject is "Coefficient of Heat Transmission in a Pressed Steel Radiator."

Mr. Verner reads paper.

The paper was discussed by Mr. Verner, Mr. Newport, Mr. Busey and Mr. Donnelly.

President Hale then asked Mr. Cooper to present his report as chairman of the committee appointed to represent the Society at the International Congress on School Hygiene.

Mr. Cooper read report after which it was voted to accept and place it on file.

Of the committee appointed by you to represent the Society at the International Congress of School Hygiene held at Buffalo, August 25-30, 1913, only two members were able to attend the sessions. The committee established headquarters at the Hotel Statler notifying the Chapter Secretaries and the various hospitality committees of the Congress.

The purpose of the Hygiene Congress was to familiarize the public with modern methods of hygiene as applied to children in the schools. The papers read and the addresses delivered covered a multitude of topics as will be noted by the accompanying official program. Papers were presented by members of this Society as follows: Dr. Milton W. Franklin read a paper on "Ozone in Ventilation." Mr. Dwight D. Kimball read a paper on "Some Phases of Ventilation" in which he reviewed the subject of ventilation from an engineer's standpoint. Mr. Frank Irving Cooper read a paper on "The Fire Hazard in School Buildings" illustrated by lantern slides showing school buildings planned to prevent loss of life from panics.

One of the most important events so far as ventilating engineers were concerned was a round table conference of the medical profession presided over by Prof. C. E. A. Winslow. It was conceded that the CO_2 content of the air is not a source of danger in normal school rooms and that the oxygen content of the air would not be reduced to a danger point under ordinary conditions.

There was also an exhibition of scientific and commercial methods and appliances for teaching and carrying out the principles of hygiene.

Over 2,000 delegates and members were in attendance and popular interest was so aroused that overflow meetings were held in connection with such topics as open air schools and sex hygiene.

The congress was a success as there were present celebrated men bringing the results of long experience, profound study, and the deepest interest in the welfare of the children: as they compared views and stated experiences, one with another, the

conversations proved of the most attractive nature, rivalling papers read even by the greatest of the experts.

At the close of the Sessions on Heating and Ventilating Buildings, members of this Society in attendance dined together at the Committee Headquarters.

There were present at this dinner:

Mr. and Mrs. W. H. Bramn,
Mr. John D. Cassell,
Mr. Charles F. Eveleth,
Dr. Milton W. Franklin,
Mr. E. A. Scott,
Mr. W. H. Carrier,
Mr. and Mrs. F. Irving Cooper,
Mr. J. I. Lyle,
Mr. D. D. Kimball.

It was also a great pleasure to have as guests of the Society Charles Logue, Chairman of the Boston School House Commission, and J. Horace Cook, Architect to the City of Philadelphia.

The next International Congress will be held in Brussels, Belgium.

Respectfully submitted,

FRANK IRVING COOPER, Secretary.

Chairman Hale: We will hear from the committee on the National Conservation Congress. Have you a report on that, Mr. Secretary?

Secretary Scott: One year ago a committee was appointed to represent the Society at the International Conservation Congress, at Washington. A report was brought in which was quite lengthy but there was nothing in that report of pertinent interest to this Society, so that in appointing a committee to represent the Society at the last meeting, the chairman was instructed that if in his opinion nothing transpired which would be of interest to this Society, it would not be necessary to bring in a report. Last week I received a letter from the Chairman of that committee stating that there was no report to be made, as there was nothing of interest to the Society.

President Hale: The Secretary advises me that he has two reports to present, one on "Heating Coils under Fan Blast Con-

ditions"; another on "Thermal tests of Heating Boilers," which were shown at the Institute of Thermal Research in Buffalo. We have these here and if it is your wish they will be read, or we will go on with other matters. There is an opportunity to bring this up at this time, and with your permission we will do so.

Secretary Scott explained that these reports were made by committees who were appointed at the semi-annual meeting to place before the Society for its transactions a description of the manner of making the tests they had observed.

Chairman Hale: Inasmuch as these two reports are only a matter of record so that our published transactions will have a definite record as to what was done at our summer meeting, it seems inadvisable to take the time to discuss them now, because many of the members here were there and saw what was done. Mr. Cooper have you a report on School Ventilation?

Mr. Cooper: As Chairman of the Committee on Heating and Ventilating School Rooms, I report that various experiments which will undoubtedly add much to the subject of school ventilation have been continued or undertaken during the past year.

Professors of Technology are investigating the physical properties of the atmosphere. Professors at Harvard University and at the Y. M. C. A. at Springfield have continued their experiments with air washers.

Dr. Franklin and other experts are making further investigations with ozone machines and Mr. Kimball, the member of the Committee, who is also a member of the New York State Commission, is engaged with the planning for a series of experiments to be made with actual school room conditions in Public School No. 51 in New York and be further studied under laboratory conditions at the College of the City of New York.

These last experiments will extend over a period of years and will be conducted under the direction of the State Commission who have a fund of $50,000.00 for this purpose.

Your committee of itself has not conducted any experiments this past year.

Chairman Hale: There are topics for discussion set aside for this afternoon, the humidification of air for residence heating; that naturally would be a part of the paper which was read by Mr. Feldman. However, if you wish to discuss that as a topic for discussion we will give you the opportunity of discussing it now.

No discussion obtained in regard to the topic, but Mr. Chew

spoke in a complimentary way of the value of the work done by the Massachusetts Chapter both in investigation and in procuring new members. He also spoke in a similar strain in regard to the work of the other chapters.

President Hale then asked the Secretary to read the paper of H. G. T. Theorell on the Heating Practice in Sweden.

Secretary Scott read paper. The paper was discussed by Mr. Donnelly and Mr. Davis after which it was voted to print the paper in the volume of transactions.

Secretary Scott: We have also a very comprehensive paper written by our member, Mr. Gustav Debesson, of France. You will find this a very complete paper with illustrations and I commend it to you as giving the status of the art in France. I hope to have this paper from the Publication Committee to read it before the meeting to-morrow.

Mr. Chew at this time asked the privilege to discuss the printed topic "Reserve and Research Fund." Considerable discussion took place in regard to this topic when it was voted that the Council should take the matter under consideration when they were working on amendments to the constitution and by-laws.

The session adjourned at five o'clock on motion which was duly put and carried.

Third Day—Morning Session

Thursday, January 22, 1914

Mr. A. B. Franklin the Vice-President, took the chair, and called the meeting to order at 11:00 o'clock a. m. The first paper this morning is the "Life of Building Power Plants," by C. M. Ripley.

Mr. C. M. Ripley read his paper.

The paper was discussed by Mr. Kent, Mr. Verner and Mr. Bolton after which Mr. Ripley replied to the questions raised.

Chairman Franklin: The next paper is that by Prof. John R. Allen "The time Element in Determining Radiation."

In the absence of Prof. Allen the paper was read by Mr. Macon.

The paper was discussed by Mr. Kent, Mr. Hart, Mr. Donnelly, Mr. Bolton, Mr. Davis, Mr. Barron and Mr. Verner.

The Chairman: Now, there will be read a paper on the "Heating Practice in France," by Gustave Debesson, of Paris. Mr. Macon will read that paper for us.

The paper was read by Mr. Macon and was discussed by Mr. Barron, Mr. Bolton, Mr. Hart, Mr. Donnelly, Mr. Kent, Mr. Verner and Mr. Davis, after which a vote of thanks was passed to Mr. Debesson for his interest in preparing the paper.

Secretary Scott: I just want to call attention to a little change in the program this afternoon, that is, the report of the Committee, considering standards for the guidance of the Committee that is framing a model Compulsory Ventilation Law. They are at work on that this morning, and they are going to bring in a report this afternoon, in which they are going to recommend the temperature to which a school room should be heated, the humidity, the minimum amount of dust that should be allowed, etc. There is an opportunity for the Society members to do valuable work in helping the Committee.

We hope to have a large attendance this afternoon, as there will also be a discussion on the constitution.

The business of the session being completed, the meeting adjourned at 1 p. m.

Third Day—Afternoon Session

Thursday, January 22, 1914

The meeting was called to order by Vice-President Franklin at 2:30 p. m.

Chairman Franklin: This afternoon, the first paper, and the only paper, I believe that has not been read, is "Heating Practice in Germany," by H. W. E. Muellenbach, Hamburg. Our Secretary, Mr. Scott, will read that paper.

The Secretary: This paper was sent in by Mr. Muellenbach in German, and had to be translated. I have not had very much time to give to it since it came back from the translators, and there may be some words in here which are translated incorrectly. However, the reading of the paper will show that. Reads paper.

In view of the fact that the paper had only just been read to the members, it was voted that the paper should be printed and discussed at some future meeting.

The Chairman: That finishes the papers that we have on the program. There are, however, a number of topics that should at this time be disposed of, if the society wishes to discuss them. The first one is "The Standard Pitch for Steam and Return Mains." Is there any desire to discuss that topic? The Chair has no desire. "Standard Specifications for Cast Iron Radiators." Is there any desire to discuss that topic?

Mr. Donnelly: Mr. President, we want to get something started. I sent in that suggestion, so I might say a little bit about it. I believe at a former meeting, we said something about standard specifications. We have been trying to get a test on different heights and widths, and placings of radiators, and trying to get a little more information; it seems as if we might get a standard specification of cast iron radiators. I do not know that I would be prepared to write one, but it might include a radiator of sufficient strength to stand pressure, and joints of sufficient durability; it might include the quality of the material to come up to a certain standard, it might also define the work which the radiator should do under standard conditions.

Those I have not given any detail thought to, but it seems as if a radiator might be specified as a standard construction, without naming the manufacturer, or particularly the type in detail, in much the same way as the standards of wrought iron or cast iron fitting pipe is specified. I would like to hear the views of some of the members.

The Chairman: Any further remarks on this topic? The next topic, if there is nothing further to be said on that topic, is: "The Efficiency of Radiators Enclosed Beneath Seats and Behind Grills."

If there are any members who have had any experience on that subject, I think it is one that might be profitable, if they would present their views at this time. If not, we will pass on to the next topic, to the topics of this afternoon.

The first one will be "The Proper Heating or Ventilation of Store Windows." Are there any remarks upon that topic? The next topic is "Horizontal versus Vertical Loops in Wall Radiation." The next is "Co-Efficient Values of Heat-Transmission Through Walls of Different Building Construction." Has anyone any experience with fractional valves?

Mr. Verner, I would like very much to see the manufacturers of fractional valves and the like get some information out that will tell us what drop in pressure will take place in their valves,

to deliver so many pounds of steam at certain entrance pressures to the valve. The heating and ventilating engineers are sadly behind the time when it comes to making an analysis of the steam distribution in various appliances.

Let us look over the ground of the turbine people and find out what they have done. With regard to the steam turbine, they have it down to an absolute science, and they know what they are doing and what they are dealing with. I would like to see more experiments conducted, so that we could figure out what pressure of the steam is used up in the radiator in the piping, and we need specials when handling a certain amount of steam at certain pressures.

Mr. Otis: I would like to answer the last gentleman in this respect: I think it is the theory of all fractional radiator valve manufacturers that the valve, when wide open, will allow a sufficient flow of steam to fill the radiator and yet give practically no pressure at the outflow, and from this condition, by the movement of the valve, to cut the steam supply so that it will fill any desired portion of the radiator. Theoretically a table of correct sizes could be arranged, but practically it would be merely guess work.

I do not believe any table could be made that would give correctly the amount of steam that would flow into the radiator at any given position of the valve, for there are too many other governing conditions. We all know from experience that it is practically impossible to accurately control the initial or boiler pressure and that the condensation in the radiator depends entirely upon the surrounding atmospheric temperature.

A table that would give correct sizes for a piping system with an initial pressure of two pounds, would be entirely inadequate when the pressure dropped to eight ounces. So a system arranged under an eight ounce initial pressure would be out of balance if the steam pressure should creep up to two pounds.

Under a fixed and stable pressure correct tables can be arranged, but for ordinary installations with a possibility of varying the initial pressure it is an impossibility.

Mr. Donnelly: Mr. President, Mr. Verner seems to have set down, as the requisite, that the standard fractional system designs to use all the heat in the radiator, and allow no steam to pass to the return. In that case, I presume they have in the German and French method, an open return, but there are some systems on the market, which have a closed return, in which the

cycle is closed, and which is capable of carrying pressures, or working at four, six or eight ounces.

I have talked with men who worked with Tudor and who had experience with adjusting fractional valves, 20 to 30 years ago, and they never could get an engineer to keep the pressure uniform in the boiler, and the engineers would never leave the fractional valves alone.

Mr. Chairman: Any further remarks on this subject? If not, there is another subject here that we will continue this experience meeting on, and that is a topic left over from Wednesday afternoon of "The Experience in Heating Concrete Construction." Is there any gentleman who wishes to speak upon that subject?

Mr. Otis: In order to start the ball, I will give my experience.

I am going to take two examples, both of which were concrete buildings, but my troubles came from the roof construction, which, of course, was concrete. In the first place, on one building it showed in the upper story, a ceiling four feet below the roof, and the roof was to be an eight inch slab of concrete, with eight inches of slag on top, all covered with the usual method of a concrete roof. It looked all right, I figured out my radiation, and put in the job. The other case, we did not have any such ceiling but we had a four inch slab, with six inches of slag on top of that, and then covered with tarring. In the first job, when the building was finished they had left off the false ceiling, and I could not heat the building. In the second job, I found out that in zero weather, I had to figure the leakage through as I would figure a concrete slab; I found in zero weather that the eaves were dropping; and the floors were cold.

Mr. Lewis: I think too often the tendency on the part of the heating engineer is to put in additional radiation, to take care of trouble in heating and that this tendency is one of our very serious weaknesses, which we should correct. We should insist on tighter windows, warmer walls or false ceilings, when the same are of improper construction or if we have to spend the money ourselves, we had better spend the money in making the building right, rather than providing more radiation, thereby cutting down in the future, the cost of operating the plant. I have had a number of installations of that sort where a wiser investment was made by repairing the building than by adding to the heating plant. Very often, with leaky windows, uninsulated steel

ceilings on top floors, solid concrete roofs, etc., the building can be made tight easier than the heating apparatus can be increased, and thereby the owner is saved additional useless fuel cost for years to come.

Mr. Hart: I might relate an interesting experience. It does not bear directly upon concrete walls, but it does on something that we are confronted with now, and that is a metal sash. A great many of the metallic window sashes being put on the market to-day, are not as tight as the old wooden sash, that we were used to, and provided for, and in a number of cases it is difficult to know what to do. We had one case where we failed to heat the building, and we went back and increased the radiation 33 1-3 per cent. It was in an office building, and after we had made the change, we still got a complaint that the people could not inhabit those offices, as they were too cold. These buildings were provided with automatic regulation, and we went back and looked over the building, and found in nearly every instance, the automatic control thermostat thermometers registered 70 degrees or over; nevertheless, the offices were not habitable, on account of the draft, and it became necessary for them to admit that we had fulfilled our contract, and they spent considerable money in stopping leaking joints in the building afterwards. I think they had no further trouble after they got the sashes reasonably tight.

Mr. Davis: If I may be allowed to digress—it is not strictly to the talk before us; but the amount of radiation necessary to put in afterwards depends entirely on the amount of the leakage you figure on, according to the best data on leakage that we have, the average leakage through a window crevice is something like three cubic feet per minute for each 1-32 of an inch in width of crack per lineal foot. That is, a crack in the window 12 inches long, one thirty-second of an inch wide, will leak as an average, three cubic feet of air per minute. That is based approximately on 15 mile wind, which is probably the average winter conditions. The average metal sash, such as Mr. Hart speaks of, will be very nearly one-eighth of an inch wide in the crack, and you can readily see that there is room for trouble. The Baltimore & Ohio office building in Baltimore, was one of the first large office buildings that I know of, built with hollow steel sashes; the heating in that building was laid out, I presume, fairly liberal, but on the north and west side of that building the radiation was practically doubled and the elevator shafts

for about eight or ten stories, were lined with radiators, but they still have trouble with this building being cold.

Mr. Hart: I do not want to occupy the floor a length of time, but Mr. Davis brings up a subject that might bear considerable discussion and thought experimentally, and that is the leakage in buildings, because in office buildings it is quite a serious subject, and bears directly on the construction of the building. We all know that in the leakage through windows, on the side on which the wind blows, the draft comes in at the bottom of the building, and out at the top. In one building in Chicago, the engineer is quite an intelligent man, and he has been trying to get some data on that for two years; he has devised all kinds of devices for taking care of the draft pressures, and has collected some very interesting data. He has tried to determine how much air he has to heat, and what the saving will be, by putting in doors on various floors, and stairways, to block off this chimney effect on the tall buildings, it is a very interesting subject. With reference to where the contractor is responsible, it ceases on leakage through a metal sash. We recall the task of the Chicago Hall, where we were roasted pretty hard in the newspapers with the failure of the heating, and they have a sash to windows, 12 feet high, a bronze sash, and the cracks in some instances were three-quarters of an inch, and the snow blew in, so that they could not work in the room at all. We finally convinced them that they could not hold us responsible for that condition.

Mr. Ed. K. Munroe: Mr. President, as a matter of interest, I would like to relate an experience that I have had during the past year; viz.: in the heating of quite a large concrete building in the city of Baltimore, Md.

We have a building there, The Industrial Building, it is 247 feet long by 150 feet deep, it having two courts and being shaped as the letter "E." It has seven stories and a well lighted basement, is of concrete construction on steel frame work.

I have not figured the glass surface as relating to the side walls but would not hesitate to state that at least three-quarters of the outside wall exposure consists of glass, three-sixteenths inch thick, wired. The window sashes are of steel and are cemented into the walls practically air tight. In the center of each sash there are several six light pivoted sash for ventilation, around which is the only possible air leakage, which is slight.

The entire building is heated by means of cast iron wall radiators placed under the windows on the outside walls only.

The point I desire to make is that we guard against two possible mistakes, to which I will refer later on.

The building was designed by one of our leading mechanical engineers, who apparently figured out the radiation amply large, with the exception of, as was later proven, the seventh floor. I might say that I was not surprised, because there was so little air leakage, and the fact that it was a concrete building did not effect the conditions seriously, except as regards the roof, which I attribute to the thickness of the walls.

The lack of heat in the entire seventh floor was the only source of trouble last winter, and this is the main point of my remarks.

The roof being only five inches thick, consisting of concrete slab with a cinder fill and slag roofing, proved a remarkable conductor of heat as shown by the rapid melting of the snow and the lack of comfort in the room below, there being no air space below the roof which formed the ceiling of the seventh floor, which averaged 16 feet high.

The radiation originally installed was 40 per cent. greater than that on the lower floors which was considered sufficient to care for these conditions. It became apparent to me from the early fall that this was not to be the case.

When the building was being heated during the very cold weather, whilst the inside temperature was around seventy degrees in the lower floors and halls, the temperature was anywhere from fifty to sixty degrees on the seventh floor, depending on the amount of snow on the roof.

When it became apparent that it was absolutely necessary, the owners had installed an additional 5 foot section on top of each and every 8 foot section of wall radiator in that entire floor, which together with the 40 per cent. already installed, netted 100 per cent. more, or just double the amount of radiating surface for the top floor having the roof exposure as for any other floor in the building.

This in my experience was unprecedented, and I will add that it worked out absolutely correct, as now the temperature throughout the building is about as even as it could be without a temperature controlling device, of which there is none in this case.

This also had the effect of increasing the velocity of steam in the risers to a very considerable extent, and made it necessary to carry in very cold weather from two to three pounds greater steam pressure, and here is the other point I desire to make.

I am convinced that the size of the risers feeding such a condition should be one size larger than the radiator connection, and also that by so doing the steam pressure at the boiler may be kept nearer normal, I particularly refer to low pressure gravity work, viz.: from 2 to 5 lbs. pressure.

Our experience in this case was that while the risers were not too small to fill the radiators on the seventh floor when the outside temperature was 20 degrees or lower, but the pressure at the boiler had to be increased to reach the seventh floor; and by increasing the pressure at the boilers from three pounds to six pounds gauge we could fill the top radiators entirely, whereas with two pounds pressure, with 30 degrees outside temperature it could be accomplished before the additional radiation was installed.

Again I found the top radiators were inclined to pocket the air, particularly with lower steam pressures and only when the plant was being operated during the day and not during the night.

We insisted on the plant being run day and night, and so not allow the system to get full of air: after they began this plan there was not a bit of trouble experienced in heating the entire building with from three to six lbs. gauge pressure.

Last Saturday afternoon, I approached the building with the engineer and he said to me, "I am very much gratified, Munroe, that we did not have a single complaint from any one of the tenants in that building, during the last few days; during which period the temperature had been down below zero day and night.

This proved conclusively that the plant was absolutely adequate.

I will also state that the coal consumption did not increase to any considerable extent by reason of the addition of the radiation on the seventh floor, which fact I attribute to the temperature of the floor having been raised from 55 to 70 degrees and there maintained the condensation was proportionately lessened in the original 60 per cent. of the radiation.

This system is a two pipe Jenkins Positive Differential system, and is working most satisfactorily.

The main point I desire to make is that in a concrete building we must install sufficient radiation on the top floor, and I am convinced of this fact, that in similar buildings if we can get our main steam lines installed in the top floor next to the roof and feed downward, we will avoid considerable trouble.

Mr. J. W. H. Myrick: The ventilation in a new modern hotel in this city was so bad that they had to put a shaft through the building. I was talking with one of our Boston friends yesterday morning at our headquarters hotel. He said, "Are you going to stop for breakfast?" I said, "Yes, have already scented mine." We were coming down the elevator shaft. Now, this inside suction, in this great big elevator shaft, running to the top of the building, is analogous to a great big chimney, and your heat is going to go up and through that, and there is nothing more natural, taking along whatever odors can escape to that point. At breakfast it was chilly, and my friend said, "I had to change my seat in the dining room at the same hotel, on account of the cold air coming in through the window." This question of inside suction, and leakage of cold air, you have to consider, and it is very important.

At the Algonquin Club of Boston, Professor Woodbridge, of the Institute of Technology, guaranteed a draft up through their billiard room flue. The down-draft was so severe that it burst the steam coils, because there was a big winding staircase, which took everything up through the center of the building.

You have got to have doors to cut off that inside suction, the same as for fire protection, and at Back Bay, Boston, the chimney flues are covered with all sorts of devices to try to create a draft in a small flue; and inside suction makes down-draft. That inside suction has fooled a great many engineers.

With regard to the Everitt High School, Massachusetts, I was called to look that building over, and one of our members was the engineer. There were two great big huge shafts going right up through the building. The top rooms did not need any increased radiation, as Brother Munroe said. They had the whole heat of the whole building, and it was so hot that they had to open all the windows, and that spoiled the ventilation system of the whole building. In the toilet room, particularly, they had a nice outlet, but no inlet. That I have found in 50 per cent. of the school houses I have been in. The ordinary school room has the inlet and outlet, but this toilet had simply an outlet, the doors opening into the big hallway, which were continually open, made a down-draft, in the supposed outlet flue taking all the odors of the toilet room up through the whole building.

Mr. Davis: Mr. President, the question which Mr. Munroe brought up, about the drafts through a building, is one of the

questions that I think deserves a great deal more attention than has been given to it.

The Secretary presented the Auditor's report which read as follows:

We have gone over the books of the Secretary and Treasurer and found them correct and in accordance with the statements made.

Signed { FRANK K. CHEW, ARTHUR RITTER.

The Chairman called for the discussion under the head of new business and Professor Kent presented some views in relation to the amendments to the constitution which were to be submitted to the members for approval or otherwise.

After considerable discussion by a number of the members, the proposed changes were discussed section by section and so voted on after which the Council were directed to prepare a ballot with the necessary explanations as to the reason for each of the changes; said ballot to be submitted to the members for their approval at a date to be selected.

Chairman Franklin: We have now completed all the business of the meeting except the installation of the officers. Mr. Samuel R. Lewis, the President elect, also Mr. Edmund F. Capron and Dwight D. Kimball, Vice-Presidents elect, will now be escorted to the Chair for installation.

Mr. President, it gives me great pleasure at this time, to inform you of your election and to felicitate you on the honor conferred by the American Society of Heating and Ventilating Engineers in calling you to this high office.

I trust as the year goes on your attention will be so given to this office that it will prove the wisdom of the members in conferring upon you this high office.

To the Vice-Presidents, my word is this: It is well-known that a Vice-President is usually considered a zero, so to speak, and looked upon a good deal in that way, but, having occupied the office myself as Vice-President, I have thought that perhaps there was something more than being a zero in connection with the office, and so it occurred to me that the President should be signified in this way, as—1. A Vice-President, perhaps a zero —0, but with one Vice-President it makes—10. With two Vice-Presidents you have 1-0-0—100. So that, Mr. President, by the

support of your Vice-Presidents, you stand for 100 men, and the work of 100 men will be expected from you by the aid of these two able supporters.

The Managers will now come forward, and the Committee will also escort Mr. James A. Donnelly, the treasurer.

The following Managers came forward:

Samuel R. Lewis,
Edward F. Capron,
Dwight D. Kimball,
James A. Donnelly,
John F. Hale,
John R. Allen,
W. M. Macon,
Frank T. Chapman,
Jas. M. Stannard,
Frank G. McCann,
Frank Irving Cooper,
H. M. Hart.

The Chairman: Mr. Treasurer, it is the pleasure of this society, knowing your good work in the past, to continue the office upon you. They show their confidence in your faithfulness, and in your ability to conduct the office of Treasurer. As you have done well in the past, so I desire, and the members desire, that you shall do well in the year to come. I trust that the members looking upon their Treasurer will find that it is their duty to see that he is supplied with funds.

Gentlemen of the Board of Managers, I also felicitate you in your selection as the men who are to govern this body for the coming year, and I trust it will be your pleasure, as well as your duty, to in every way you can, forward the interests of this society, and you can do nothing better than be faithful in the attendance at the Council meetings. I have been lax in duty myself at times, and in connection with that, I am prepared to give you very good advice—not to let it be said of you that you have been non-faithful.

I congratulate you one and all upon the high honor that has been conferred upon each of you, and we now will be glad to hear from the President, Mr. Samuel R. Lewis. Mr. Lewis, you are now President. It is my pleasure to retire from the rostrum.

(Here Mr. Samuel R. Lewis took the Chair.)

Mr. Lewis: Gentlemen, I cannot think of anything that could be a greater pleasure than to have this installation carried out by one of the older members of the Society, than whom there is no more loved member in our whole Society, and I am very sure of that. I think it is particularly fitting that the reins of office should have been turned over by one of our older members to this organization of officers, who are all younger members. We have a great standard which we must try to meet, and I believe there is no question but that I will have the finest support that any man could get in attempting to make that 100 per cent. efficiency that has been marked on the blackboard. For my part, I will work as hard as I can to that end. I thank you very much.

Mr. F. K. Chew: Mr. President, I would like to say that I am very much pleased to think that an old custom which has fallen into abeyance in recent years has been renewed, because Mr. Franklin happened to be in the Chair. I have always felt, that the office with which the Society offers a man, is an active responsibility, rather than the passing honor, and I believe that it should be a part of the business, or the ceremony of every annual meeting. A man being elected, instead of hurrying out of town, should feel it part of his duty to be here, he pledged in some measure that during the year for which he is elected, he will give some time and attention to the work of the Society. I make, as a suggestion to the President, who has the power to appoint an Installation Committee next year, that he can select the older members, or charter members, as he pleases, to see that the obligation, or rather the responsibility which these men assume, is not assumed too lightly. It has been assumed too lightly too many times. Everybody has been pleased with Mr. Franklin's action in renewing something that was formerly done. I suggest to the President he provide for the installation of the officers next year.

President Lewis: I think the suggestion is excellent, and the Chair will promise to remember it. I think it will be hard to find any of the old guard who could do this thing in so pleasing a way as Mr. Franklin did it to-day. I was deeply moved and touched by the way he did it.

Mr. Hart: Mr. President, I would like to take this opportunity to offer a vote of thanks to the Entertainment Commit-

tee, both the ladies and gentlemen, for the loyal and most excellent manner in which they have provided the entertainment for the visitors to this meeting, and I move that a rising vote of thanks be given to this Committee.

This was seconded and carried unanimously.

The President: The Committee appointed yesterday to report on the suggestions to be made to the original Committee of Compulsory Ventilation, did not report. Mr. Busey will now deliver that report. Perhaps it is wise to say that this is not for adoption; this is for reference to Professor Hoffman, the Chairman of the original Committee, and the Chair understands that the intention of the Society is that this original Committee should be continued in office, so that they may revive and complete this model law.

Here Mr. Busey read the report, dated January 21, 1914.

The President: I believe no action is necessary on this report, and it will be forwarded to the Chairman of the Committee on Compulsory Legislation.

The Chair wishes to thank the members of that Committee for the work they did, and to assure them that they will be held to the promise that they have made, to furnish additional information.

Is there any other business? In the failure of any suggestions of other business at this time, I would like to say something that my embarrassment caused me to forget a few minutes ago, regarding the Committee for Compulsory Ventilation, and for Legislation. I think the Committee is too large. I think it is too cumbersome. With the permission of the Council, I think we will try to reduce the size of that Committee, picking out the members who are effective. The policy of the administration, insofar as the President can influence it, is going to be toward the requiring from specific members, all the specific things, which they will be called upon to do. Their promise will be secured, and we will keep after them and make them furnish what they agree to furnish.

The policy of the administration is going to be as far as possible, to have Committees acting locally, so that they may meet and by contact get a little better action.

Mr. Myrick: I would like to ask you to ask the Council, if they might not allow the Chapter to put it before them to consider the names for membership of the Legislative Committee,

so that we might have people in our Commonwealth whom we might know are members of the association.

The President: I think that is a good suggestion. That goes along the line of one of our discussions this afternoon. It is highly desirable that one administration carry over from the previous administration, or the old administration, and get the benefit of their experience, and they will know who will work and who will do things, and who can be depended on. That will be taken into consideration.

A meeting of the Council or Directors will be held immediately.

On motion the meeting adjourned at 5:45 p. m.

LIST OF MEMBERS AND GUESTS PRESENT AT THE TWENTIETH ANNUAL MEETING, JANUARY, 1914

New York, January 20, 1914

MEMBERS

Addams, Homer
Armagnac, A. S.
Bradley, E. P.
Brooks, H. H.
Bradbury, C. R.
Boyden, D. S.
Badger, O. L.
Broderick, J. F.
Barron, H. J.
Bacon, J.
Barwick, Thos.
Busey, Frank L.
Bolton, R. P.
Chew, Frank K.
Cassell, J. D.
Chase, Chas. F.
Chenoweth, W. H.
Cooper, F. I.
Carrier, W. H.
Capron, E. F.
Carney, J. F.
Chapman, F. T.
Clark, W. D.
Coughlin, D. J.
Conklin, F. W.
Cyphers, J. F.
Cryer, T. B.
Driscoll, W. H.
Davis, F. K.
Donnelly, J. A.
Dornheim, G. A.
Dumond, A. A.
Doherty, P. C.
Devendorf, Wm. F.
Douglass, R. L.
Dickinson, W. S.
Edgar, A. C.
Franklin, A. B.
Ellis, H. W.
Farnham, G. D.
Franklin, M. W.
Fabricus, J. H.
Flagg, Chas. N., Jr.
Fox, E. E.
Faulkner, J. C.
Fuller, C. A.
Feldman, A. M.
Gombers, H. B.
Graham, Jos.
Gardner, S. F.
Greey, G. V.
Geiser, H.
Hayes, Jos. G.
Hill, E. V.
Hart, H. M.
Hale, J. F.
Hanbury, John F.
Hunt, R. B.
Harris, G. D.
Hellerman, H. H.
Hankin, Richard
Helmer, L.
Hall, A. Edson
Hoffman, P. A.
Hinkle, E. C.
Heath, F. R.
Issertell, H. G.
Kline, W. J.
Kiewitz, Conway
Koithan, W.
Kieb, A. A.
Kent, Wm.
Kimball, D. D.
Knowles, Arthur
Knight, G. W.
Kirk, W. P.
Kiewitz, A. A.
Lamson, F. S.

Lynd, R. E.
Lemmy, Robert
Lyle, J. I.
Lennox, F. J.
Lewis, S. R.
Mappett, A. S.
Morrison, Chas.
McCann, F. G.
Myrick, J. W. H.
Macon, W. W.
Murphy, E. T.
Merritt, J. H.
Martin, G. W.
Munroe, E. K.
Mackay, W. M.
McKiever, W. H.
Newport, Chas. F.
Ohmes, Arthur K.
O'Hanlon, George
Olvany, W. J.
Otis, J. S.
Pryor, R. W., Jr.
Pearce, C. E.
Phegley, F. C.
Quay, D. M.
Ritter, Arthur
Ritchie, Wm.
Rice, D. J.
Seward, P. H.
Strader, B. K.
Stannard, J. M.
Scott, E. A.
Shanklin, J. R.
Schmidt, G. G.
Stockwell, W. R.
Snow, W. G.
Timmis, W. S.
Treat, E. J.
Verner, W. F.
West, Perry
Weinshank, Theo.
Warsop, C. E.
Webster, Warren

GUESTS

Allalling, Harry
Ackerman, Chas.
Browne, A. L.
Bohn, E. H.
Braemer, Mr.
Benson, G. F.
Bradshaw, T. P.
Bilyen, W. F.
Chapman, H. D.
Commer, F. M.
Cheshire, W. W.
Clinton, W. D.
Caldwell, O. H.
Campbell, G.
Driggs, Leland L.
Dix, H. T.
Dugan, E. J.
DeGroot, L. P.
Dobson, J. B.
Duff, Kennedy
Davis, D.
Engle, H. J.
Engle, Al.
Eden, L. E.
Fisher, M. C.
Garfield, J. B.
Gross, L. A.
Griffin, P. C.
Heilman, C. A.
Hutton, Wm.
King, H.
Lewis, L. L.
LeCompte, W. G.
Lloyd, E. M.
Lipkleman, Henry
Lanning, E. K.
Meehan, Jos.
Marshall, W. J.
Munroe, Chas. A.
Miller, E. A.
Mott, Geo. A.
Munro, Arthur B.
Munro, Wm. R. N.
Mussellman, J. F.
McCormick, W. G.
Moffitt, H. H.
Newport, J. H.
Newman, Howard
Pfaendler, Walter
Parker, S. C.
Quackenboss, R. H.
Reynolds, T. W.
Rome, R., Jr.
Ressler, M. H.
Regnvall, Gustaf
Ripley, C. M.
Ross, C. E.
Storm, E. S.
Shear, Frank M.
Singer, E. F.
Shillady, John R.
Smith, P. C., Jr.
Surrell, John R.
Sargent, A.
Sherburne, E. B.
Tsutsumi, H.
Terrell, H. A.
Vosmaer, A.
Vitalius, C. H.
Van Innagen, F.
Webster, E. K.

LADIES

Mrs. Ruby Ross Goodnow
Mrs. F. K. Davis
Mrs. J. A. Donnelly
Mrs. F. T. Chapman
Mrs. C. R. Bradbury
Mrs. J. D. Cassell
Mrs. E. V. Hill
Mrs. F. G. McCann
Mrs. H. M. Hart
Mrs. C. F. Newport
Mrs. J. H. Newport
Mrs. John F. Hale
Mrs. H. G. Issertell
Mrs. J. I. Lyle
Mrs. Vosmaer
Mrs. Braemer
Mrs. F. L. Busey
Miss H. R. Innis
Mrs. A. A. Kiewitz
Mrs. E. K. Munroe
Mrs. W. M. Mackay

PAPERS

OF THE

TWENTIETH ANNUAL MEETING

January 20, 21 and 22, 1914

CCCXXXI

REPORT ON WORK OF VENTILATION DIVISION OF THE CHICAGO HEALTH DEPARTMENT FOR 1913

BY E. VERNON HILL, M.D.

A brief summary of work done by the Ventilation Division of the Chicago Health Department, for the past year, is shown in the accompanying Chart 1.

The heading "plans examined" refers to the total number submitted to the Division during the year, of which 473 were approved as complying with the requirements of the ordinance.

The total number of installations inspected comprises ventilating equipments of every kind, from an exhaust fan in the alley wall of a restaurant kitchen to the complete installation in a large theatre.

Of the various classes of buildings inspected, including theatres, lodge halls, schools, etc., some are equipped with mechanical ventilating devices and some are not; in each instance, however, a record is made, with a scale drawing of the building or room, with the proper notations as to the number of occupants, temperature, relative humidity, etc., and also the results of air analyses and bacterial counts.

License applications inspected and approved cover new buildings or those that were remodeled or converted into theatres or halls where an amusement license is required.

Complaints received refer mostly to letters received by the Department complaining of the poor ventilation of theatres and street cars.

Street car test runs refer to tests made on 16 street cars which were equipped with various natural or mechanical systems of ventilation. These test runs occupy usually from 4 to 7 or 8 hours, and require two or sometimes three men. Anemometer readings are taken at the outlets or inlets, as the case may be, to determine the amount of air actually supplied to the passengers. Dust counts and culture determinations are also made, and observations of temperature, relative humidity, etc.

Street car inspections refer to inspections of cars in service in which temperature observations and air samples were taken.

The 536 tests of equipments installed include 206 theatres in which the installation has been made in the past six months, 114 theatres that were built or ventilated during the preceding winter, and 216 existing theatres, schools, and other buildings in which the equipment is more than two years old.

Of the 1236 air samples analyzed 920 were taken in theatres, schools, etc., and 316 in street cars. Of the cultures 380 were

CHART 1.—WORK OF VENTILATION DIVISION FOR YEAR ENDING DEC. 30, 1913

Plans examined	1029
Plans approved	473
Installations inspected	1167
Buildings Inspected—	
Theatres	630
Dance and lodge halls	95
Schools	12
Churches	9
Police stations	12
Department stores	17
Restaurants	21
Bakeries	5
Others	201
Scale drawings made	894
License application inspections	318
License applications approved	289
Complaints received and inspected	134
Total re-inspections	2009
Street car test runs	16
Street car inspections	230
Tests of equipments installed	536
Total air samples taken	1236
Total cultures taken	580

taken in theatres, schools, police stations, department stores, and 200 in street cars.

In addition to the foregoing the Division has spent as much time as was consistent with the other duties of those connected with it in making dust counts and bacterial examinations of the air in various places, tests to determine the rate and method of diffusion of air in street cars, schools, and theatres which were equipped with various types of mechanical ventilation, and some other tests, such as the comparing of different types of Pitot tubes, air sampling apparatus, and similar work that was necessary to enable the department to form standards of comparison.

PRIMARY SENSE IMPRESSION

Methods employed.—All inspectors are instructed to note the impressions experienced immediately on entering an auditorium, street car, or other enclosed occupied space, and to record the same carefully. It is interesting to observe how soon the sensory nerves become educated to slight changes in air conditions in those inspectors who are on night duty investigating the ventilation in theatres. The following incident will illustrate: A mechanically ventilated theatre was visited by one of the inspectors on a cold evening in November. This theatre has a system which supplies 25 cu. ft. of air per person per minute and was in operation at the time of inspection. The condition of the air appeared very satisfactory and no samples were taken. The inspector left the

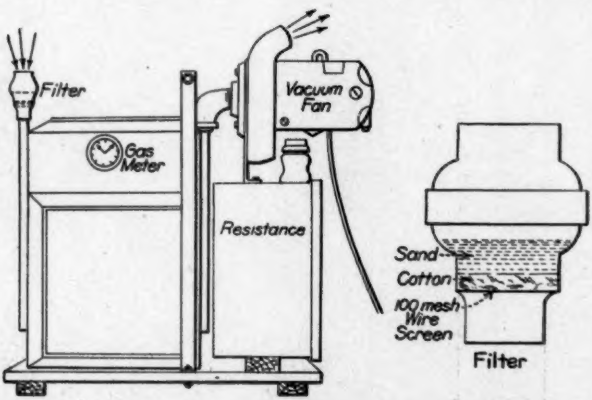


CHART 2.—MACHINE FOR MAKING DUST DETERMINATIONS

theatre, but having forgotten some detail returned in about 15 minutes. He states in his report that on entering the door he immediately observed a change in the condition of the air from his former visit; it was close and oppressive, the temperature appeared higher, and there was a distinctly objectionable odor. He went immediately to the manager and asked him what was the trouble. The manager feigned ignorance, so the inspector investigated. He found that a recirculating duct, which was installed ostensibly for the purpose of warming up the theatre before the show began, but not intended to be used during performances, had been opened so that the air in the auditorium was recirculated and no outside air supplied. The inspector further states that on two occasions in other theatres the same thing has occurred, and he can detect the

change by the primary sense impression within 10 minutes from the time that the outside air supply is shut off and the recirculating duct opened.

It appears from the analyses of 538 inspections where air samples were taken that while the sense impression is usually a reliable

CHART 3.—COMPARATIVE RESULTS ON FOURTEEN POORLY VENTILATED AND THREE WELL VENTILATED THEATRES

Numbers of Colonies on Plates							
Poorly Ventilated				Well Ventilated			
Theatre	5 min. plates	10 min. plates	CO_2	Theatre	5 min. plates	10 min. plates	CO_2
							7.5
1		450	41	6	8		6.0
							13.0
	95		42.5		12		10.5
							8.5
	54				14		9.0
							9.5
	160				16		8.5
2	27		18.5		17		
	30		19.5	7	7	12	7.
	35				3		8.
3	27		29		14	27	14.5
	100		20.5			20	12.
	100			8	11	16	15.5
4		52	15.5		6	12	16.
	24	97	17		12	20	12.
		43					12.
5		24	14				
		60					
9	34	57	8.5				
	30	53	11.5				
10	55	83	9.5				
	25	50					
11	12	50					
	30	30					
12	15	29					
	23	64					
13	66	82					
	46	157					
14	271	521					
	213	221					
15	65	51					
	44	54					
16	14	72					
	38	62					
17	51	70					
	18	30					
Totals	1702	2462	247		120	107	169.5
Numbers	28	24	12		11	6	16.
Average	60.78	102.58	20.58		10.4	17.83	10.59

index to air conditions, such is not always the case. In audiences where people are unclean, or where a strong odor, such as garlic,

is present, the composite sense impression is obscured by the impression on the sense of smell. Also, when the outside temperature and relative humidity is high the impression in a theatre is worse than the actual conditions warrant. When we say the air conditions in a theatre are good we mean that the temperature is not above 70 deg.; the relative humidity not above 65 per cent.; the dust count not over 4.2, and the number of colonies on a five-minute plate not

CHART 4.—COMPARATIVE RESULTS IN TWO WELL AND THREE POORLY VENTILATED THEATRES—FILLED HOUSES

Number of Colonies on Plates							
Well ventilated				Poorly ventilated			
Theatre	5 min. plates	10 min. plates	CO_2	Theatre	5 min. plates	10 min. plates	CO_2
1		450	41	6	8		7.5
							6.0
	95		42.5		12		13.0
							10.5
	54				14		8.5
	160				16		9.0
12	15	29			17		9.5
	23	64					8.5
14	271	70		8	11	16	15.5
	213	521			6	12	16.
	51	221			12	20	12.
	18	30					12.
Total	900	1385	83.5		96	48	128.
Number	9	7	2		8	3	12.
Average	100	197.85	41.75		12	16	10.66

SUMMARY

	Totals	Totals	Averages	Averages	CO_2	CO_2
Theatres	5 min. plates	10 min. Totals	5 min. plates	10 min. plates	Averages	Averages
All	1822	2209	46.7	73.63	364.8	17.371
Well ventilated	120	107	10.9	17.83	170.0	10.59
Poorly ventilated	1702	2102	60.78	87.58	247	20.583
Filled Houses						
All	986	1433	58.	143.3	193.5	19.35
Well ventilated	96	48	12.	16.	114.	9.5
Poorly ventilated	900	1385	100.	197.86	83.5	41.75

over 20. Under such conditions the carbon dioxide analyses will not be above 12 parts.

DUST

Chart 5 gives the number of dust particles per cubic foot of air found in certain locations and under varying conditions. These determinations are made by means of a dust machine, a drawing of which is shown in Chart 2. It consists briefly of a gas meter through which the air is drawn by means of a high pressure centrifugal fan. On the inlet of the meter is situated the filter, which consists of a glass receptacle containing 25 grams of sugar on a

CHART 5.—DUST COUNTS UNDER VARIOUS CONDITIONS

Sample No.	Date	Hour	Location	Weather conditions: Temp. deg. F.	Weather conditions: Relative humidity per cent.	Weather conditions: Barometer in.	Weather conditions: Wind	Size of sample in cu. ft.	Dust count per cu. ft.	Remarks
3	4-23	3:20	Roof of City Hall	80	40	29.05	S.25	50	4,580,000	All samples from roof were taken from west side
5	4-24	4:25	Roof of City Hall	73	60	29.04	S.28	50	4,160,000	Rain previous night
8	6-10	10:30	Roof of City Hall	58	56	29.70	E.5	50	5,900,000	Occasional sprinkling
9	6-10	11:15	Roof of City Hall	61	38	29.66	E.7	50	5,600,000	
13	6-11	10:25	Roof of City Hall	67	39	29.55	S.W.8	50	7,580,000	
14	6-11	11:15	Roof of City Hall	68	45	29.52	E.7	50	7,200,000	
15	6-12	10:48	Roof of City Hall	71	40	29.36	E.6	50	8,740,000	
15	6-12	11:50	Roof of City Hall	71	40	29.36	E.6	50	6,068,000	
16	6-13	1:48	Roof of City Hall	86	34	29.15	S.W.11	50	6,100,000	
17	6-13	2:36	Roof of City Hall	86	34	29.15	S.W.11	50	5,900,000	
22	6-21	9:36	Roof of City Hall	59	92	29.16	N.8	100	412,000	Rain previous night. Raining at time
1	4-21	5:33	Window in research room	65	30	29.27	S.15	10	10,400,000	
2	4-22	2:50	Air intake in research room	78	40	29.08	S.W.14	10	7,800,000	
4	4-24	2:49	Air intake in council room	73	60	29.04	S.28	50	4,240,000	Rained previous night
6	4-29	1:30	Car. 644 Ogden Ave.	52	50	29.31	N.E.6	10	19,600,000	Car not in service, doors and windows closed
7	4-29	2:30	Car. 644 40th Ave.	53	44	29.29	N.E.6	10	12,300,000	
10	6-10	2:52	Car. 5708 Cottage Gr. Ave.	62	32	29.63	N.E.10	10	7,700,000	Floor intake
11	6-10	2:05	Car. 5708 55th St.	62	32	29.63	N.E.10	10	5,660,000	Car not in service
18	6-20	2:05	Air washer Otis Bldg.	87	46	29.02	W.21	10	6,800,000	Roof intakes
19	6-20	2:15	Air washer Otis Bldg.	87	46	29.02	W.21	10	7,000,000	
20	6-20	2:35	Air washer Otis Bldg.	87	46	29.02	W.21	10	2,700,000	
21	6-20	2:44	Air washer Otis Bldg.	87	46	29.02	W.21	10	2,500,000	
23	6-27	3:15	Fan room Otis Bldg.	96	42	29.15	W.11	10	2,400,000	
24	6-27	4:00	Fan room Otis Bldg.	96	42	29.15	W.11	50	0.0064 gms.	Evidently cotton had not been thoroughly dried
25	6-27	4:15	Air intake Otis Bldg.	96	42	29.15	W.11	10	7,300,000	
26	6-27	4:40	Air intake Otis Bldg.	96	42	29.15	W.11	50	0.0020 gms.	People walking around machine
27	7-8	12:00	S. S. Theodore Roosevelt Hurricane deck	87	50	29.03	S.13	20	630,000	

100 mesh wire gauze. From 10 to 50 cu. ft. of air is drawn through the sugar, which is then dissolved in 100 c.c. of distilled water and the dust particles counted in a Sedgwick-Rafter counting cell, with a ruled eye piece. Before collecting samples a large quantity of sugar is sifted and a control count made. During all stages of the test the greatest care must be exercised to avoid errors, due to dust falling into the sugar, filters, diluted water, bottles, pipettes, counting cells, and different parts of the microscope. The counting cell is made by cementing a rectangular brass rim on an ordinary glass slide. The internal dimensions of the same are: length 50 m.m., width 20 m.m., and depth 1 m.m., giving it an area of 1000 sq. m.m. and a capacity of 1 c.c. A thick covered glass having dimensions equal to those of the outside of the brass rim forms the roof of the same. After thoroughly shaking the bottle of sugar solution containing the dust to be counted, the covered glass is placed diagonally across the cell and 1 c.c. is withdrawn by means of a small pipette and allowed to flow in through an opening left

CHART 6.—MISCELLANEOUS OBSERVATIONS OF THE NUMBER OF BACTERIA ON PLATE CULTURES

MISCELLANEOUS

Date	Location	Place of Observation	Period of Exposure	Count		Remarks
6-20	Otis Bldg.	Before Washer	1:0	74		
6-20	Otis Bldg.	Before Washer	1:0			
6-20	Otis Bldg.	Before Washer	2:0	123		
6-20	Otis Bldg.	Before Washer	0:30	1		
6-20	Otis Bldg.	After Washer	1:0	9		
6-20	Otis Bldg.	After Washer	1:0	5		
6-20	Otis Bldg.	After Washer	2:0	24		
6-20	Otis Bldg.	After Washer	0:30	6		
6-27	Otis Bldg.	Air Intake	1:0	15		
6-27	Otis Bldg.	Before Washer	1:0	6		
6-27	Otis Bldg.	Before Washer	1:0	22		
6-27	Otis Bldg.	Back of Baffles	1:0	6		
6-27	Otis Bldg.	Back of Baffles	1:0	4		
6-27	Otis Bldg.	Fan Room	1:0	2		
6-27	Otis Bldg.	Fan Room	1:0	3		
7-8	S.S. Theodore Roosevelt	Hurricane Deck	1:0	0		Raining, stormy,
7-8	S.S. Theodore Roosevelt	Cabin Deck	1:0	0		rough, forward
7-8	S.S. Theodore Roosevelt	Cabin Deck	1:0	0		
7-8	S.S. Theodore Roosevelt	Cabin Deck	2:0	0		
7-8	S.S. Theodore Roosevelt	Cabin Deck	2:0	1		
7-8	S.S. Theodore Roosevelt	Cabin Deck	5:0	1		
7-8	S.S. Theodore Roosevelt	Cabin Deck	10:0	1		
7-8	S.S. Theodore Roosevelt	Cabin Deck	10:0	2		
7-8	S.S. Theodore Roosevelt	Cabin Deck	20:0	20		Near sea sick
7-8	S.S. Theodore Roosevelt	Cabin Deck	20:0	29		passengers, aft
				1	2	Average
7-30	C. A. Stevens & Bro.	First Register	2:0	51	118	84.5
7-30	C. A. Stevens & Bro.	Second Register	2:0	51	62	56.5
7-30	C. A. Stevens & Bro.	Third Register	2:0	48	32	40.
7-30	C. A. Stevens & Bro.	Fourth Register	2:0	19	32	25.5
7-30	C. A. Stevens & Bro.	15 ft. from No. 1	5:0	15	13	14.
7-30	C. A. Stevens & Bro.	15 ft. from No. 2	5:0	27	35	31.
7-30	C. A. Stevens & Bro.	Near Elevator	5:0	11	14	12.5
7-30	C. A. Stevens & Bro.	Radiator by Ex. Desk	5:0	21		21.
7-30	C. A. Stevens & Bro.	Exchange Desk	5:0	35		35.
7-30	C. A. Stevens & Bro.	Cashier Desk	5:0	15		15.

by the diagonal piece of glass. The covered glass is then turned so that it completely covers the cell, which is now ready for the count.

The ocular micrometer consists of a square ruled upon a thin disc of glass, which is placed upon the diaphragm of the ocular of the microscope. The square is of such size that with a certain combination of objective and ocular, and with a certain tube length of the microscope, the area covered by it on the stage is just 1 sq. m.m. Some of the results obtained by the use of this apparatus are given on the accompanying chart. It may be said that if the proper care is exercised the results will be very accurate, but as the equipment is heavy and cumbersome the apparatus is not suitable for use in occupied theatres. We have recently imported an Aitken portable dust counter, but have not up to the present time had sufficient experience with this machine to give an opinion as to its practicability for this work.

TEMPERATURE AND RELATIVE HUMIDITY PERCENTAGE

Temperatures are taken by standard chemical Fahrenheit thermometers in at least four locations in an auditorium. These are checked with the temperature observed on the dry bulb thermometer of the sling psychrometer when relative humidity determinations are made.

CULTURES

Cultures are made on standard Aagar plates, as recommended by The American Public Health Association for water and milk analyses. These plates are exposed for 5 and 10 minutes in theatres and 2 minutes in street cars. They are incubated for 48 hours at room temperature and the colonies counted. Recently Dr. Caldwell of the Municipal Laboratory, who has done most of our bacteriological work, has devised a very simple apparatus for making determinations of the number of bacteria per cubic foot of air. This consists of a galvanized iron tube 13 in. long and about 3½ in. in diameter, capped at both ends. The tube is of such dimensions that its cubic content is exactly 2 liters. In taking a sample of air the caps from both ends are removed and the tube passed through the air by a horizontal motion until the observer is confident that all the air originally in the tube has been replaced by the air in the room. The upper cap is now replaced and the tube inverted over an uncovered Petri dish and allowed to stand for 20 minutes. At the end of that time it has been determined that all of the bacteria in the tube will have settled on the plate, which is then incubated and the colonies counted. Dr. Caldwell has made repeated tests with this simple device, with very satisfactory results. If a clean

plate is inserted after the expiration of 20 minutes no colonies will appear. This gives us a very simple and convenient method of making quantitative determination of the number of bacteria in a unit volume of air.

CARBON DIOXIDE

In all of the cases reported air samples were taken by means of a Paquelin cautery bulb in 25 c.c. rubber stoppered bottles by the displacement method. The samples were analyzed in the laboratory

CHART 7. RESULTS OF TESTS ON TWO GENERAL METHODS OF STREET CAR VENTILATION

Cars in Service			
Floor Intake		Ceiling Intake	
Car Number	2 Minute Colonies on plates	Car Number	Colonies on plates 2 Minute
644	146	5708	7
	52		47
	33		95
	200		16
	138		34
	301		20
5740	168*		
	78*		
	93*		
Total	1209		219
Number of plates	9		6
Average	134.33		36.5

Note.—*Recorded counts are of one minute plate counts.

On car No. 1557 two samples of air were taken through a sand filter, the bacteria counts were 305.5 and 379 per cubic foot.

SUMMARY

Ventilation system	Floor intake		Ceiling intake	
	Car in service	Car not in service	Car in service	Car not in service
Total number of colonies on all plates	1209	1293	219	379
Average number on a plate	134.33	215.5	36.5	47.375
Dust counts		19,600,000 12,300,000		7,700,000 5,660,000

with the Peterson-Palmquist apparatus, except in some cases where the analysis was done by the modified Pettenkoffer method, for the purpose of checking results. After experimenting with the various

devices we have concluded that the displacement method of taking air samples is as accurate as any that has been devised, and much more convenient. The Peterson-Palmquist apparatus is accurate within ½ part in 10,000 if the analyses are carefully made.

DESCRIPTION OF CHARTS

Chart 1 shows the work done by the Division of Ventilation during the year 1913.

Chart 2 is a drawing of the machine used for collecting air samples and making a count of the number of dust particles per cubic foot. On the right hand side of the chart is also shown the filter. If the filter is used with sugar, this is dissolved and a dust

CHART 8. RESULTS OF TESTS ON STREET CARS WITH CEILING INTAKES
BACTERIA COUNTS ON ALL CARS

Floor intake		Ceiling intake	
Car Number	Colonies on 2 minute plates	Car Number	Colonies on 2 minute plates
644	441	5708	7
	140		47
	52		95
	33		16
	146		34
	200		20
	138		51
	301		24
1557	132*		37
	96		16
	136*		10
	348*		52
5740*	168		125
	78		64
	93		
Totals	2502		598
Number of plates	15		14
Average	166.8		42.7

Note.—* Recorded counts are 3/2 of one minute plate.

AVERAGES FOR CARS

Car number	Total count for all cars	Number of plates exposed on cars	Average number colonies per plate
644	1451	8	181.375
1557	712	4	178
5740	339	3	133
5708	219	6	36.5
5708	379	8	47.375
Total	3100	29	576.25
Average	106.89		113.25

count made with a Sedgwick-Rafter counting cell, as previously described. In some instances we use sand in place of sugar in the

filter, plate the sand in Petri dishes and make a count of the number of bacteria in a unit volume of air.

Chart 3 shows comparative results of 14 poorly ventilated and 3 well-ventilated theatres. The plates are exposed for 5 and 10 minutes and samples analyzed for carbon dioxide at the same time. Although the total number is not sufficient to warrant positive conclusions, the averages at the bottom of the chart are interesting.

The upper part of Chart 4 compares results in 3 poorly ventilated against 2 well-ventilated theatres. Nine plates exposed in the poorly ventilated for 5 minutes as against 8 in the well-ventilated give an average bacteria count of 100 in the former as against 12 in the latter. Totals and averages are again shown on the lower part of the chart.

Chart 5 is a tabulation of dust counts made in various localities and under varying conditions. The number of the sample, the date and hour the same was taken are noted, together with the location. Under "Weather Conditions" the first column refers to the temperature; the second to the percentage of relative humidity; the third the barometric pressure, and the fourth to the direction and velocity of the wind.

Chart 6 shows miscellaneous observations of the number of bacteria on plate cultures.

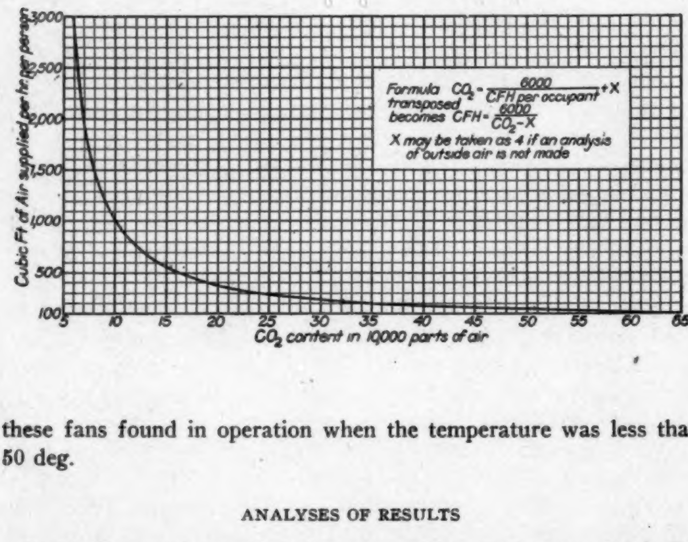
Chart 7 was prepared after making repeated tests of two general methods of street car ventilation. All cars on the chart, with the exception of No. 5708, are provided with a system of ventilation which draws the fresh air in through slots or intakes in the floor over heaters. Serious complaint was made by street car patrons of the large amount of dust in some of these cars, especially those in which the supply depended on a natural system, that is, globe ventilators on the roof which depended for their action on the velocity of the wind and the movement of the car. To meet these objections No. 5708 was equipped with a mechanical system of ventilation in which the air supply was drawn in through the roof through especially designed diffusing intakes, and exhausted by means of a cone fan situated at the rear of the car below the floor line. The results of tests with this equipment showed that the average number of bacteria on 2-minute plates was reduced about 75 per cent. as compared with those where the air is drawn in through the floor.

Chart 8 is a repetition of the one just described, except that results with the ceiling intakes are compared with different cars.

Chart 9 was prepared by Dr. Caldwell, showing results of his examination of 17 theatres. These theatres were visited at random, without any knowledge beforehand as to how they were ventilated.

It will be noted from the chart that in place of sense impression notations Dr. Caldwell noted more particularly conditions as to occupancy and sanitation. The interesting feature in this chart is the comparison of the carbon dioxide analyses with the number of bacteria on both 5 and 10 minute plate exposures. It will be observed by studying the figures that where the carbon dioxide analysis is low the number of bacteria is correspondingly so, and where the CO_2 analysis is high there is a correspondingly high bacteria count. On this chart where notations are found that certain exhaust fans are installed it should also have been noted that in no instance were

CHART MODIFIED FROM A STUDY IN THE VENTILATION OF SLEEPING CARS BY THOMAS R. CROWDER



these fans found in operation when the temperature was less than 50 deg.

ANALYSES OF RESULTS

In making analyses of various inspections and tests of the Division during the past year several conclusions were forced upon us. While no discoveries have been made that are startling, I believe that they are of sufficient importance to be commented on at this time. The tendency in the past few years has been to give little or no weight to the results of carbon dioxide analyses, or to the amount of air supply, and to emphasize the effects of a high temperature and relative humidity on the heat regulating functions of the body. This is due, undoubtedly, to the experimental work of Fluegge, Leonard Hill, and others, which indicates that high temperatures

and high relative humidity are responsible for the feeling of depression in poorly ventilated rooms and that carbon dioxide in itself is harmless. Pettenkoffer demonstrated 50 years ago that carbon dioxide was harmless under conditions ordinarily found even in the worst ventilated rooms. He and his successors continue, however, to use the CO_2 analyses as an index of other supposedly injurious substances in respired air. Repeated investigations by physiological chemists since that time have failed to find any poisonous or harmful ingredients in respired air, but the fact should still be emphasized that while such substances have not been found it would be unscientific and illogical to assume that they do not exist. We must, however, discard the belief that carbon dioxide is a measure which can be used to determine the presence of such impurities.

The value of analyses of air for its carbon dioxide content has not changed, only its method of application. It is a measure, and a very accurate measure, of the amount of fresh air supplied and by reason of the fact that the fresh air supply bears a direct relation to the number of bacteria in the air, it is in this way a reliable index to the amount of dust and bacteria. I do not wish to be understood as making the statement that the amount of CO_2 necessarily bears a direct relation to the number of bacteria under all conditions, for this is not the case, but in theatres, dance halls, etc., where the air supply is not washed or recirculated our observations have convinced us that the larger the air supply (consequently, the lower the carbon dioxide content), the smaller the number of bacteria. This is to be explained in the following manner: When an audience is admitted to a theatre or other unoccupied room a large amount of dust and dirt is brought in on the shoes and clothing. This dust and dirt soon becomes liberated, stirred up from the floor, and soon fills the air. If no air change is produced by either a mechanical or natural system of ventilation the dust particles, with their attendant micro-organisms, remain suspended. If an adequate amount of fresh air from an uncontaminated source is brought into this theatre there is a dilution and removal effect, which soon clears the air of these suspended particles and very soon reduces their number. In this way we have come to regard a low carbon dioxide content as indicating a low bacteria count, and several hundred observations bear out this statement.

A careful analysis of the accompanying charts will show that where the air supply is approximately 20 cu. ft. per person per minute, or more, the bacteria count will be less than 20 on a 5-minute plate. Where the air supply falls to 5 or 10 cu. ft. per person per minute the bacteria count will be correspondingly high.

RELATIVE HUMIDITY

Repeated complaints were made to the Ventilation Division during certain periods in the Spring, and again in the Fall of the year, regarding the ventilation of certain large auditoriums. Investigation of these complaints in theatres, one theatre in particular which was supplied with 600 cu. ft. of air per person per hour, revealed the following conditions: On those days when the relative humidity outdoors was rather high, 55 to 65 per cent., and when the outside temperature was about 60 deg., we found that the humidity in the theatre rose to 73 or 74, or as high as 75 per cent. A simple mathematical calculation will show that where the difference in the outside and inside temperature is not over 10 deg., and when the outside relative humidity is high, the aqueous vapor added by the occupants of the theatre raises the inside humidity to an almost unbearable degree. In situations of this kind 1200 to 1800 cu. ft. of air per person per hour is required to relieve this condition.

In conclusion I would say that to provide sufficient air movement to equalize the temperature and to reduce excessive humidity under the conditions above described, but particularly to maintain a bacterial content compatible with health, a minimum of 1200 cu. ft. of air per person per hour is required. This means a carbon dioxide analysis of 9 parts per 10,000.

DISCUSSION

Dr. Hill: I feel that an apology is due the Society for the small amount of data that is shown on the charts in this report. This is not because more material was not available, but because it was impossible to tabulate the data at hand, owing to pressure of departmental work. I have prepared, as you will note, a chart of the entire work of the division for the past year. The charts and tabulations following this were prepared some months ago and I have not had the opportunity to bring them up to date, as I had expected.

Prof. Kent: I note "when the relative humidity is high, the aqueous vapor added by the occupants of the theatre raises the inside humidity to an almost unbearable degree." I am glad to see that statement because for the last few years we have been hearing that we have not been having enough humidity.

Dr. Hill: I would like to say in this connection that in a large number of observations of relative humidity in school

rooms and theatres, it is very rare, indeed, that we have found less than 30 per cent. Occasionally we have, but it is usually a question of too much humidity rather than not enough.

A Member: I would like to ask Dr. Hill if he has established the best temperature at which to keep auditoriums of that character.

Dr. Hill: We never have.

Professor Kent: Mr. President, there seems to be one little lapse that the Doctor might fix; the lapse is that in some cases the air is thoroughly mixed, but we have had papers before the Society showing that there was a tremendous difference in the amount of CO_2 in one part of the room and the amount in another.

Dr. Hill: Prof. Kent answered his own question before he had finished. I did not go into that matter in detail, it being understood that this depends principally upon the diffusion of the air. The larger the number of samples taken, the more accurate the results will be. The Ventilation Commission of Chicago have been carrying out some experiments along this line. We made some tests in a theatre recently where the air was exhausted from the auditorium by means of two 24-inch fans placed on either side of the picture screen and about 12 feet above the floor. The fresh air supply was drawn in at the opposite end of the theatre through two stacks of "vent" about 6 feet above the floor. We placed standard candles (lighted) in every seat to give off CO_2 and heat, just as the occupants in an auditorium would do under actual conditions. In these tests we make observations regarding air diffusion, etc., but what I wish to speak of particularly is the CO_2 tests. In this case, the air entered at a temperature slightly higher than was originally intended, owing to a slow velocity through the coils. We took 18 air samples, six below seats, six five feet above the floor and six one foot below the ceiling. These samples were analyzed for CO_2 to determine in which of these three strata the analysis would be the highest. It was expected that the CO_2 from the candles being of a higher temperature, would be found in excess near the ceiling line, but owing to the fact that the entering air was warmer than the air in the theatre, it rose to the ceiling, and being low in CO_2, probably about four parts, we found this strata contained the highest percentage. The strata 5 feet above the floor contained 8 to 12 parts of CO_2. The strata under the seats 6 to 7, and the strata near the ceiling 7 to 9.

Dr. Franklin: The question of temperature is perhaps one of the most important in connection with ventilation. Human beings differ in many ways: weight, color, likes and dislikes, etc.; but in one thing they seem to be fairly similar and constant and that is in the amount of heat dissipated. As between the Eskimo and the African negro, there does not exist a great difference in the amount of bodily heat lost in 24 hours. Human beings lose heat by convection and radiation in exactly the same way as any inert physical body, so that the amount of heat lost depends only on the difference in temperature between it and the surrounding air. The human body is a physical body at a constant temperature, so that aside from its limited compensation for different temperatures of the surrounding medium, the colder the latter the more heat will be lost in a given time. In order that the loss of heat shall be constant, clothing of different characters is chosen according to the temperature of the air. When a man wears clothing he is surrounded by a volume of air that diffuses only slowly so that the factors of convection, radiation, and diffusion of heat adjust themselves to maintain the heat lost at a constant figure.

The correct temperature at any place is a matter of choice. It is a function of the natural temperature of the body and of the amount and nature of the clothing worn. The former being a constant and the latter being a variable, the desirable temperature is likewise a variable. For any given room there is one temperature and only one, which may be called correct, that is: which will cause the normal amount of heat to be abstracted from the body, but this temperature is a variable, depending only on the clothing.

In the north, where people wear fur and cover large portions of their bodies, the correct temperature may be one thing; whereas, in the south, where they cover less of their bodies, the correct temperature may be entirely different, but in both cases they dissipate the same amount of heat.

In order to maintain a fixed temperature in a room, the desired temperature having once been decided on, there is one amount of air and only one for each quantity and temperature of entering air which will maintain this temperature in the room. If the entering air is cold, only a small quantity is needed because the amount of heat given off by the people will warm it to the room temperature; whereas, if the entering air is warmer and nearer the temperature of the human body, a very large quantity is required in order that the room temperature may not rise.

Closely interlaced with all this is the question of humidity. Certain empirical mathematical relations between the temperature and moisture content of air are known. Now assuming that any class of persons, that is: occupied with any class of activity, give off a constant average of moisture per unit time, we can write a mathematical expression for the exact quantity of air to be admitted into any room having given the following:

The Number of People in the Room.
The Magnitude of the Room.
The Character and Extent of Wall Surface.
The Outside Temperature.
The Desired Temperature in the Room.
The Desired Humidity in the Room.
The Temperature of the Entering Air.
The Humidity of the Entering Air.

Briefly considered, the problem is this: Each person dissipates the same amount of heat per hour and the same amount of moisture per hour. The problem of ventilation is to keep the air in the room at such a temperature and degree of humidity that with the clothing normal for the location, the compensatory mechanism in the human skin shall not be taxed beyond its normal limits in either direction to maintain the occupant in comfort.

CCCXXXII

A WARD-COOLING PLANT IN A HOSPITAL

BY A. M. FELDMAN

The Mt. Sinai Hospital of New York City is the first hospital, so far as the author has been able to learn, to establish an experimental plant for cooling two small wards, which were used during the past summer in treatment of children suffering from gastroenteritis. The superintendent of the hospital selected two rooms on the first floor of the children's ward for the purpose in mind. The dimensions of the rooms are 8 ft. x 10 ft. x 14 ft. and 11 ft. x 15 ft. x 14 ft. respectively. The author was retained in an advisory capacity and finally designed the cooling plant and supervised its installation.

Outdoor air is forced by a motor-driven Sirocco fan through a water-chamber in which the water is cooled by brine coils. From this chamber the air is forced through an upper chamber filled with additional brine coils, thence through short ducts into the wards, where the cooled air enters near the floor level. Open transoms allow the warmer strata of vitiated air to escape from the top of the rooms. Some air also escapes through the entrance doors when used by the nurse and the physician. The possibility of warm air entering from the corridor is eliminated. The cooling plant proper is located in the basement under room No. 1, as shown on plan, Fig. 1. It consists of a Greef air washer, a motor-driven blower and coils through which cold brine is forced, an eliminator for removing the free particles of moisture and heating coils for re-heating the air, if so desired.

In the type of air-washer used, the air is forced through a body of water. A float-controlled valve maintains a uniform water level as the supply water is lost in evaporation. A brine coil of 5 sq. ft. is immersed in the water of the washer, and 66 sq. ft. of additional cooling surface, divided into three sections, is installed in the upper shell. Thus the air is washed and partially cooled by

passing through cold water and then by passing over the cooling coils above. Brine is taken from a return main in connection with the refrigerating system of the building, pumped through the coils by means of a small motor-driven centrifugal pump and delivered to the same return.

For the purpose of keeping a record of the condition of the air, two Bristol recording thermometers were installed in the large room, one to register the outdoor temperature, the other the temperature of the room. The relative humidity was ascertained by

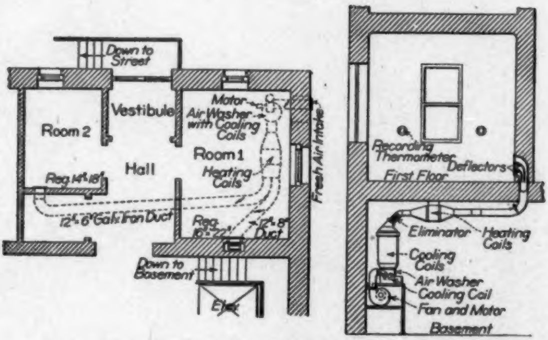


Fig. 1. Location and Details of Air-Cooling Plant

means of a sling psychrometer. The experiments were conducted during the entire summer of 1913. Observations were taken in room No. 1 where three to four children were under treatment. Air was delivered at the rate of 250 cu. ft. per minute. In addition to the temperature of this room, a record was kept of the temperature and relative humidity in the main childrens' ward where no cooling was done. Typical charts of the recording thermometers, are reproduced in Fig. 2, showing the records for the hours from 9 a. m., July 30, to 9 a. m., July 31, 1913. The outdoor temperature, as will be noticed, was 86 deg. at 9 a. m. rising gradually to an average of 92 deg. between 1:30 and 4 p. m., then dropping gradually to 78 deg. between 5 p. m. and 6:30 p. m., when it began to rise again. The indoor temperature of the room was maintained at an average of 72 deg. between 9 a. m. and 3 p. m., rising gradually to 74 deg. at 7 p. m., which latter temperature was maintained until midnight, then rising to 75 deg. until 4 p. m., dropping again to 74 deg. until 7 a. m. and to 72 deg. at 8:45 a. m.

The relative humidity was observed at different intervals dur-

VIEW OF THE AIR WASHING AND COOLING APPARATUS

The fresh air enters the duct at the point A in the upper sash of the window. At B may be seen the blower which delivers to the cooler-washer and cooling coils in chamber C. The pipes D D, are brine pipes tapping the return brine line of the general refrigerating system of the building. At E is the small pump for securing a positive circulation of the brine. The brine pump delivers to the washer through the pipe G and to the three coils above the washer F, F, F. At H is the delivery duct from the air washer and J is the re-heating chamber, fitted, as indicated, with thermostatic control, the reheating coil also divided into three sections and the sections having hand valve control in the usual way. Incidentally the brine pipes are provided with thermometer wells and a thermometer is shown at the side of the duct to obtain readings of the air on delivery from the air washer cooling system. A thermometer was also arranged for on the delivery side of the reheating chamber, so that arrangements are available for making a comprehensive test.

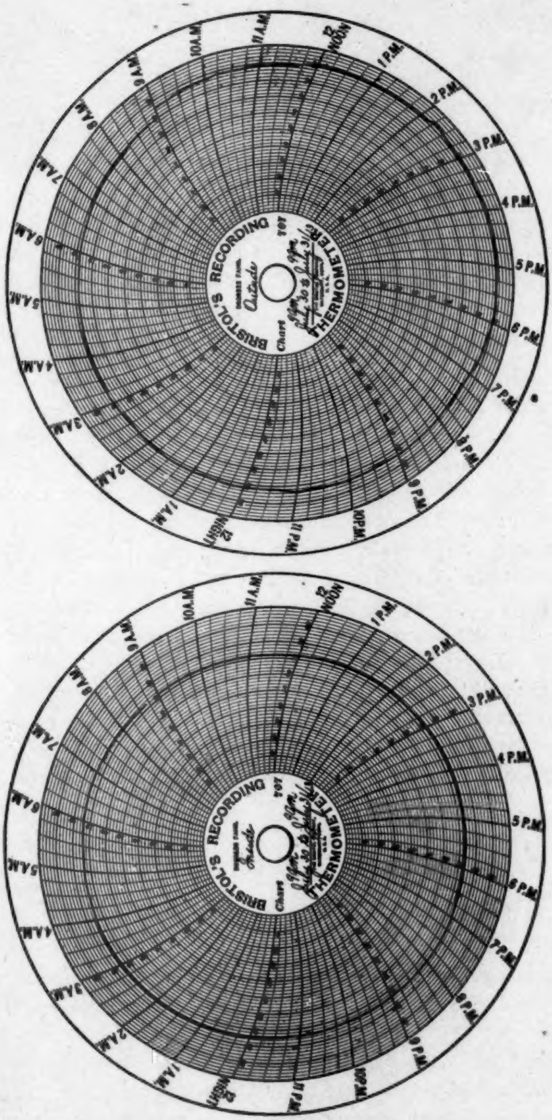


Fig. 2. Charts Showing Record of Inside and Outside Temperatures for July 30-31

ing the day. In the artificially cooled room, the relative humidity varied between 41 per cent. and 76 per cent., making an average of 60 per cent. for readings taken on 25 different days. In the main ward, the relative humidity varied during the same period from 35 per cent. to 80 per cent., with an average of 59 per cent. The temperature in the cooled room varied during the period of observation from 63 deg. to 74 deg. This latter temperature was reached only on one day when the temperature on the street rose to 93 deg. The average temperature in the cold room for 252 readings was 69 deg. during a period of 42 days. The record of the outdoor temperature during the same 42 days, taken at 8 a. m., 12 a. m., 4 p. m., 12 p. m., and 4 a. m., were 77 deg., 79 deg., 80 deg., and 70 deg. respectively.

It is interesting to note that while low temperatures were obtained in the cold room, the relative humidity was approximately the same percentage as that in the main ward with higher temperature, thus indicating that the absolute humidity was reduced by the process of cooling. As beneficial results were reported, it may be inferred that air-conditioning by lowering the temperature and reducing the absolute number of grains of moisture produces the effect, notwithstanding that the relative humidity may still show a high percentage. This deduction the author also made in a series of other observations conducted at the plant designed by him for the Kuhn, Loeb & Co. banking offices, as reported in a paper read by the author at the semi-annual meeting of the Society in July, 1909.

The observations of the temperature and relative humidity were taken by Dr. Louis H. Levy in charge of the ward. I want to acknowledge thanks to him and also to Dr. S. S. Goldwater, the superintendent of Mt. Sinai Hospital, for furnishing me with a set of the recording thermometer charts and data of tests.

As the hospital wanted to experiment with low temperature only no tests were made with re-heating the air as designed.

As evidence that the effects of the cooling were satisfactory, a letter from Dr. S. S. Goldwater, received by the author under date of January 8, is quoted as follows:

"Dr. Henry Heiman tells me that inasmuch as only 13 cases of gastro-intestinal diseases were treated in the artificially cooled ward, it is hardly justifiable to present definite conclusions as to the therapeutic value of this measure. Gastro-enteritis was not particularly prevalent during the summer of 1913, and the number of cases

treated in the hospital was very much below the number usually treated; in fact, the thirteen patients who were treated in the cooled ward, were practically the only gastro-enteritis cases available for our first tentative studies. Thus there was no opportunity for a comparison of the behavior of these cases with that of patients treated for the same disease in the open wards, under ordinary conditions. While we are unable at the present time to draw far-reaching conclusions, we have nevertheless gained the impression that the babies treated in this ward were on the whole more comfortable, cried less, rested and slept better than the patients kept in the other wards of the children's service during the same time. We hope to have the opportunity of studying this important question more thoroughly next summer."

CCCXXXIII

COOLING TWO ROOMS IN A COUNTRY RESIDENCE

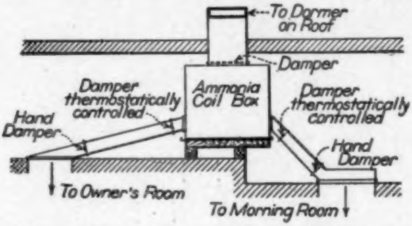
BY A. M. FELDMAN

For the country residence of Mr. Paul M. Warburg at Hartsdale, N. Y., the author was called upon to provide a design for cooling the owner's bedroom and morning room, in conjunction with the installation of a small refrigerating plant to be used for pantry and kitchen refrigerators. The rooms are 28 ft. x 23 ft. x 11 ft. and 14 ft. 9 in. x 18 ft. x 10 ft. respectively. This problem was solved by installing a cork insulated box with 300 ft. of 1 in. galvanized iron pipe in the attic immediately above the rooms. The top of the box was connected with a short duct to the roof dormer for taking in fresh air, and from the ends near the bottom two galvanized iron ducts were connected to the ceiling registers of the two rooms as shown on the accompanying plan. Fresh air enters the top of the box, is cooled and drops by gravity through the registers to the floor of the rooms. The cooled air there moves forward and escapes through the partially opened windows, thus creating the necessary change of air for ventilation.

The author took advantage of the thermostats which were installed in the rooms in connection with the heating system and connected them with diaphragm levers to control dampers in the ducts, thus providing means for automatically shutting off the cold air in case the rooms would become colder than desired.

Tests showed a temperature in the rooms of about 6 deg. lower than out of doors.

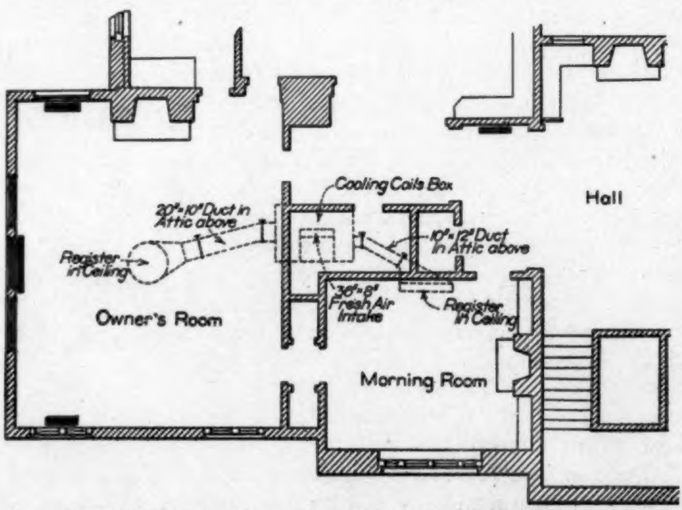
The cooling box is provided with two narrow but deep so-called congealing tanks filled with brine with part of the coils submerged therein. The chilled brine in these tanks furnishes enough cold storage to cool the air part of the night when the refrigerating



Elevation of Cooling Box and Connections in Attic

machine is not in operation. The ammonia piping is arranged in three coils with valves as shown in the accompanying drawing. The coils are cooled by direct expansion of ammonia.

The structural details of the box are also indicated in an accompanying illustration, which shows the position of the congeal-

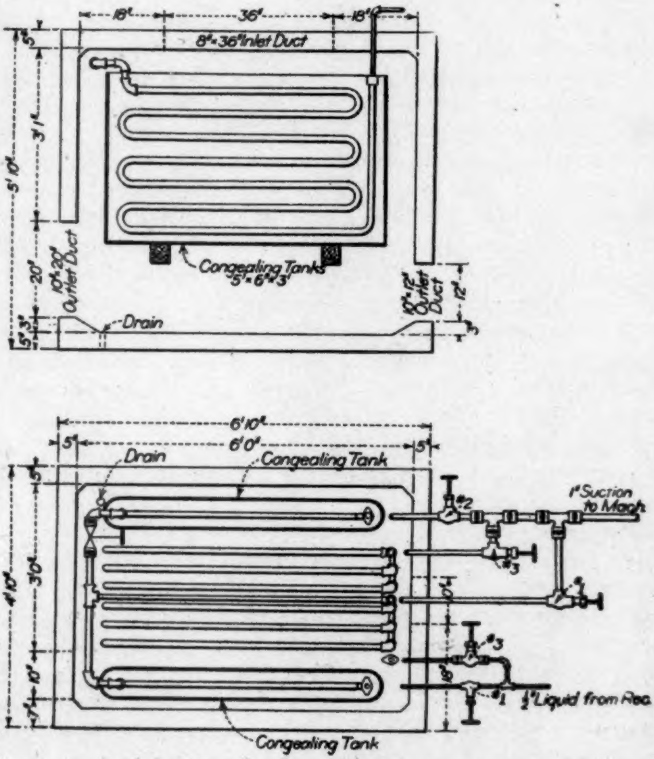


Floor Plan Showing Installation of Cooling Ducts Above Ceiling

ing tanks and coils and the location of the valves. These valves give flexibility to the system in operation, as the ammonia may be expanded in one or both congealing tanks or in the third coil independently.

To prevent possible leaks, all the ammonia pipes throughout the installation are welded together by means of the Goldschmidt thermit process.

All the ammonia pipes and ducts are properly insulated with cork covering. The ammonia compressor is a 5-ton, two-cylinder



Detail of Air Cooling Refrigerator and Connections

vertical machine driven by an electric motor through a short belt, with a belt tightener idler.

In order not to waste it, the condensing water is pumped back to the general domestic elevated supply tank by means of a small motor-driven centrifugal pump. The water was never found to have any odor or taste of ammonia.

DISCUSSION

Dr. Levy: I am glad to be able to be here this afternoon and I am indeed very glad to have had the invitation to discuss Mr. Feldman's paper.

The question of cooling wards in a hospital is of important interest just now on account of the newer facts that have been discovered in recent investigations that have been carried out in the last two or three years. I am indeed sorry I am not more of an engineer so that I might discuss this paper from the engineer's standpoint—or at least from the combination viewpoint of an engineer and a physician. The proposition of using cold air for treatment of diseases is not a new one. As far back as 1875, Dr. Von Moltke, who was one of the physicians connected with the German army under Bismarck, found that he could get better results in typhoid cases by sending the patients to cooler parts of the country than by keeping them where the temperatures were high. I have had a talk with Lieut. Col. Charles Woodruff, who has done such wonderful sanitation work in the Philippine Islands, and he found his experiences were similar. In such cases as typhoid and dysentery, he found that they had gotten far better results when they sent these cases to cooler atmospheres. He told me in the cases of dysentery before they had a specific, that the mortality was much decreased by sending these cases to the cooler parts of the country.

It has been my observation and I think it is the general observation, that certain diseases are more prevalent during the summer which are not so prevalent during the other seasons of the year; and it seems plausible to assume that the temperature must have something to do with this. It seems quite probable that if you can simulate the conditions as found in the fall and the winter you can render a great aid to us. We are finding in our experience at the hospital that certain cases are much improved by cold baths, cold sponges, and even more recently Dr. O. H. Brown has described in the Interstate Medical Journal his process of treating typhoid fever by using cooled air over the patient instead of giving him cold sponges. In that way the patient lies in one position and the work on the heart is diminished. By putting a patient like that in a cooled room you are going to get the same results and you all know the aim of a physician is not only to help but cure the patient. You have also the advantage of being a help to the physician in that par-

ticular way. If by proper means you can give us the proper temperature and the necessary humidity by creating such a method you can help us. You can treat the patient, as I have already said, by cold baths and plunges, but you are disturbing him all the time, and there is nothing more sensible, there is nothing more reasonable, than that the patient should be quiet. Dr. Goldwater was kind enough to give me a clipping about ten months ago of a plant that was installed at one of the Kansas City hospitals. I wrote to them but received no reply. In that particular ward they used the pipes themselves, pipes in the walls, as I understand it. The cold air was obtained in that way by passage through these pipes. What results they obtained I do not know but regarding our own experience in carrying out these experiments, we found that the temperature throughout the entire summer, even on the hottest days, was about 70 degrees. The proposition as put forward by Mr. Feldman was to keep the temperature in that room about 70 degrees and that was carried out very faithfully. Regarding humidity Mr. Feldman has already read the results in the cooled room and the general ward, but that difference could be very well explained on account of the larger wards in which there were about 20 children, and several times during the day there were porters cleaning up the floor and in that way the moisture got into the air. We were quite fortunate in a way in being able to summarize our results last summer by the fact that of the 16 cases only one died. It is quite true that last summer the mortality was not quite so great and the cases were not quite so severe. Next summer we are going to try just the cold air alone without the humidity measurement. The usual mortality in diarrhoea cases in summer is about 50 per cent., and it is a very well known fact that in the summer there are more deaths among children due to this than to anything else.

Now, you see the problem before us. We are trying to do with cooled air just what Nathan Straus has done with his milk problem. What Nathan Straus has done you can do, by helping us to decrease the temperature in our wards so that the mortality can be kept down.

I can sincerely say that I am very glad to be here this afternoon and I thank you.

Mr. Winslow: I should like to say a word about these papers. Mr. Feldman has been with us here in the East, a pioneer in the

development of the practical application of cooling. Like other pioneers he runs perhaps unforeseen dangers. I heard one criticism of one of his cooling plants in which he will be interested. This was a cooling plant installed in one of the leading banking houses in this city. One of the partners told me that he had only one criticism of the plant but that was a serious one; when people came in there on a hot summer's day it was impossible to get rid of them for they would never leave so comfortable a place.

Dr. Levy pointed out that the cooling of rooms in summer means a great deal for health. Cooling is altogether practical, its results of far reaching importance. I am convinced that summer's heat kills more people than winter's cold. Infant mortality in summer is primarily a result of the temperature. I believe the time will come when we shall rely on this application of cool air for cure and we shall also apply it for prevention. Nothing would mean more, I think, in the reduction of infant mortality than the provision in different parts of the city of specially cooled nurseries where children who were not very well and children who were not fed at the breast could be taken during the extreme hot weather. In connection with the treatment of a number of diseases, many constitutional diseases, the cold air method is becoming more and more recognized. We have thoroughly made up our minds of its value and it is going to be perfectly simple for you engineers to supply cool air under definite and defined conditions. I think this whole question of neutralizing the extreme heat of summer and the providing of a cooled and regulated air supply in winter opens unsuspected vistas for the heating and ventilating engineers' profession, so that one day your Society, if it does not change the name, will add another word to it and call it the American Society of Heating, Cooling and Ventilating Engineers.

Mr. Feldman: I think it only right that Mr. Payson, the engineer and manager of the company, give us the exact trade name of that machine.

Mr. Payson: There is just one point in the paper of Mr. Feldman's which I would like to call to your attention. Mr. Feldman speaks of the water lost in evaporation. I am under the impression that in that plant there is no water evaporated into the air; as a matter of fact there is a water deposit in the machine from the air and the humidity is considerably lowered as it goes through the appa-

ratus. This, I believe, as Dr. Levy brought to your attention, is quite an important fact in its result in the ward, the lower humidity, and I thought there might be some wrong impression in regard to this matter. Am I right, Mr. Feldman?

Mr. Feldman: The air striking the water under pressure produces a spray, part of which is carried away with the air. The float controlled valve permits it to maintain the water level.

Mr. Payson: I believe in that particular machine the automatic float valve is simply in place so that when the machine is cleaned and drawn out and when it is refilled it will be brought up to the standard level, as I understand my portion of the equipment.

Mr. Feldman: I think perhaps Mr. Payson might be asked to describe the machine.

Mr. Payson: The machine that is referred to by Mr. Feldman consists of three essential units; the blower, which is motor-driven and the cooler, the humidifier, and thirdly, the re-heater. The blower is of standard Sirocco type, the fan being mounted on the same fan as the armature of the motor. The air is forced by the blower through an air chamber, which is shaped similar to an ordinary round elbow of galvanized iron. At this point it strikes a deflector the blades of which are shaped like those of a propeller, and as the air strikes it, it is given a rapid whirling motion. The point at which it strikes the water is right on the surface so that this motion creates a fine spray and practically atomizes the water. The air at this point passes to and around galvanized cooling coils through which the brine is kept circulating and from this point the air passes out through the eliminators. This moisture drains out into the machine, is passed through the re-heater and through the registers into the room. The air in passing through the equipment is cooled down as you all understand, and this precipitates a certain amount of moisture that it contains, so that when it leaves the eliminators and passes on through the re-heater it has much less moisture per cubic foot. This is shown by the amount of water which is flowing out into the drain. After it has left the machine it goes through the re-heater although I understand this was not used last summer. The absolute humidity in the room was considerably less than that in other parts of the hospital although the relative humidity is approximately the same .

CCCXXXIV

COEFFICIENT OF HEAT TRANSMISSION IN A PRESSED STEEL RADIATOR

BY JOHN R. ALLEN

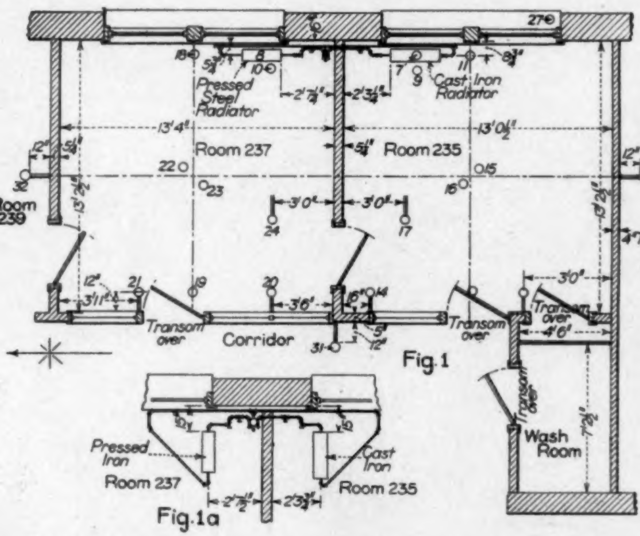
There is available very little information in regard to the heat transmission in pressed-steel radiators and this paper is presented so as to contribute some information on this type of radiation. The tests reported herein were conducted in the mechanical laboratory of the University of Michigan, by Prof. John E. Emswiler, in charge of the Experimental Laboratory. The radiators tested were 12-section, 2-column 38-in. cast-iron radiators of the Rococco type, which type was used as a standard, a 12-section, 2-column, 38-in. pressed-steel radiator, and a 12-section, 2-column, 14-in. pressed-steel radiator. The sections of the cast iron radiators were spaced 2½ in. and of the pressed steel 2 in.

The cast-iron radiator had, by actual measurement, 48 sq. ft. of superficial surface; the 38-in. pressed-steel radiator had 47 sq. ft. of superficial surface, and the 14-in. radiator had 35½ sq. ft. of superficial surface. The rated surface for the 38-in. radiators was 48 sq. ft., for the 14-in. radiator 36 sq. ft.

Two sets of tests were made, the first to determine the coefficient of heat transmission with the radiator placed under the windows and parallel to the wall, and the second with the radiator in a similar position with reference to windows but perpendicular to the wall as shown in Figs. 1 and 1*a*. Additional tests were made to see if there was any appreciable difference in the speed with which a room can be heated with the two types of radiation.

To test the relative value of the two types of radiation, two rooms were selected of approximately the same size ,and the same amount of exposed wall and window surface. The cast-iron radiator was placed in one office and the pressed-steel radiator in the other. A

plan of the offices and details of the connections are shown in the illustrations. Steam was supplied to the mains carrying 125 lb. pressure per square inch and reduced to 5 lb. pressure by a reducing pressure valve. The steam was carried from the valve to a tee and from this point a 1-in. pipe was connected to each radiator. From the return side of the radiator the water of condensation was carried through water seals and cooled in long pipe connections before going to the weighing tanks. These water seals were provided with

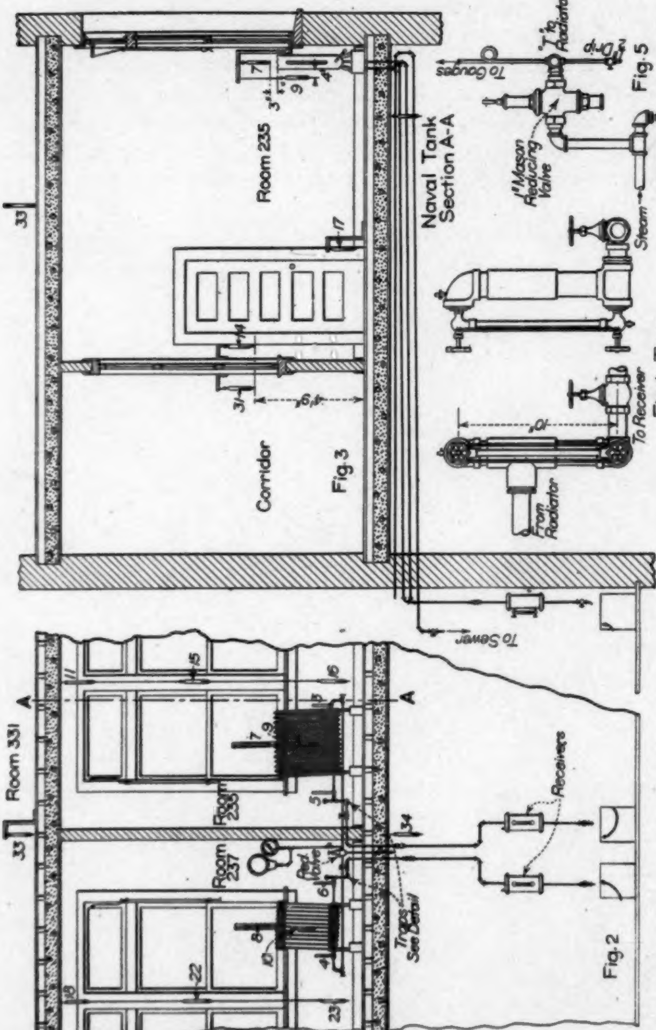


FLOOR PLAN SHOWING POSITION AND LOCATION OF RADIATORS AND THERMOMETERS DURING TESTS

Radiators were placed as shown in Fig. 1 in tests 6, 7, 10, 11 and 12 and interchanged in tests 2, 3, 4 and 5 and in test 14 as shown in Fig. 1a.

gauge glasses and the valves on the return lines were adjusted so that the water was kept at a uniform height in the wells, as shown in Figs. 2, 3, 4 and 5.

Considerable care was exercised in placing the thermometers in the rooms so as to give average room temperature. The location of the thermometers is shown in Figs. 1, 2 and 3, the thermometers being indicated by circles. In order to be sure that the conditions were practically the same in both rooms a test was made with radiators in their initial position; then these radiators were interchanged,



Details of the Equipment for Testing the Radiators

the pressed-steel radiator being placed in the room where the cast-iron radiator had previously been and vice versa. No appreciable difference in condensation was recorded.

RESULTS OF THE TESTS

Table 1 gives the results obtained from these tests.

TABLE I

Radiators	Test No. 1 Iron Cast	Test No. 1 Steel Pressed	Test No. 2 Iron Cast	Test No. 2 Steel Pressed
Gauge pressure	5.00	5.00	4.00	4.00
Absolute pressure	19.56	19.56	18.54	18.54
Temperature outside air, deg. F	31.	31.	33.5	33.5
Temperature entering steam, deg. F	227.6	228.3	224.2	223.4
Temperature corresponding to pressure, deg. F.	226.8	226.8	224.	224.
Degrees superheat	0.8	1.5	0.2	0.
Average temperature of room, deg. F	79.9	80.6	80.7	79.5
Difference steam and room temperature	146.9	146.2	143.3	144.5
Pounds of steam condensed per hour	11.29	10.92	11.53	11.22
Total B. t. u. transmitted per hour	10850.	10510.	11100.	10800.
Total B. t. u. transmitted per sq. ft. rated surface	226.	219.	231.2	225.
Total B. t. u. transmitted per sq. ft. actual surface	226.	223.	231.	230.
Coefficient of transmission rated surface	1.539	1.498	1.612	1.557
Coefficient of transmission actual surface	1.539	1.527	1.612	1.592

In test No. 1 the radiators were placed parallel to and under the windows, as shown in Fig. 1, and in test No. 2 the radiators were placed near the windows at right angles to the walls, as shown in Fig. 1a. In comparing these two tests it will be noticed that the radiators give slightly better results when placed at right angles to the walls, the actual percentage increase being about 5 per cent. In order to determine whether the furniture in the room had any effect upon the capacity of the radiator a test was made with all the furniture removed, the other conditions remaining the same; but a careful comparison of the results shows that the effect of the furniture was negligible and the results of these tests have not been given.

An examination of the table shows that the coefficient of heat transmission from a pressed-steel radiator is almost the same as that from a cast-iron radiator. The pressed-steel radiator, taking an average of ten tests, shows a slightly smaller result, the average difference being about 3 per cent., that is, the pressed-steel radiator shows a heat radiation about 3 per cent. less than might be expected from a similar type of cast-iron radiator.

RELATIVE SPEED OF HEAT

It was thought that, owing to the difference in weight of the two types of radiator used in these tests, there might be an appreciable difference in the speed with which these two types of radiation would heat the rooms and the test was made in order to determine the dif-

ference. The cast-iron radiator used weighed 316½ lb., while the steel radiator weighed 108.3 lb. It is natural to suppose that a pressed-steel radiator being much lighter would warm the room more rapidly than the heavier cast-iron radiator.

Fig. 6 shows the increase in temperature in two similar rooms, the increase being plotted on the right hand side, the abscissa being temperature and the ordinates being time. On the left hand side the ordinates are weighings of condensation in pounds taken at 10-minute intervals. The upper curve shows the increase in temperature in the room. The lower curves show the condensation. The dotted line is for the cast-iron radiation and the solid line for the pressed steel. It will be noticed that the heating effect as shown

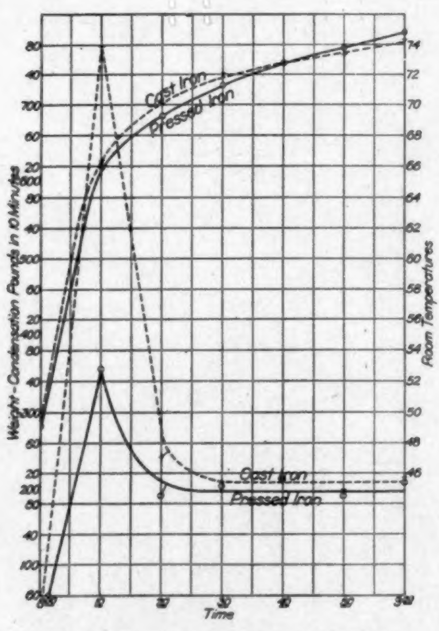


Fig. 6. Chart Showing Results of Tests

by the rise in temperature of the rooms is practically the same in both rooms and apparently these tests show that the difference in weight of the two types of radiation made very little difference in the actual rise in temperature of the rooms. The condensation curve, however, shows that the cast-iron radiator had a much more

rapid condensation for the first 10 minutes, about 3½ times the normal, but at the end of 20 minutes this condensation had almost reached the normal; by 30 minutes normal condition had been reached. In the pressed-steel radiator condensation for the first 10 minutes was about twice the normal, and at the expiration of 20 minutes the radiator had reached normal conditions of condensation.

COMPARISON OF HIGH AND LOW RADIATORS

A set of tests was also made to determine the heat transmission of two radiators of the pressed-steel type of different heights. The results show that with a temperature difference between the room and steam of 143 deg. the coefficient of transmission for the 14 in. radiator was 1.647 for the rated surface and 1.855 for the actual surface of the radiator; for the 38-in. radiator, under similar conditions, the coefficient was 1.498 for the rated surface and 1.527 for the actual surface of the radiator. These are approximately the same results as would be expected from cast-iron radiation.

DISCUSSION

Mr. Verner: The idea was to have these tests conducted under as nearly actual conditions as would occur in an ordinary room being heated by the radiator. In previous tests the radiator was set up in the laboratory and as a result the conditions under which the radiator worked were not the same as would occur when being used for heating in a room.

The office rooms in which the tests were conducted are ventilated by the ordinary method used in school buildings. These registers were closed during the tests so that the radiator took care of the heat lost from the rooms through the walls.

Mr. Davis: Going over Table 1, the results of the test, I note, that Professor Allen's results are similar to what I found about three years ago and reported at a meeting two years ago, i.e., that radiation placed at right angles to the wall or away from the cold wall, is more efficient than that placed under the window. There was considerable discussion of the matter at that time. And I am rather pleased to see that Professor Allen's results corroborate mine.

Mr. Verner: The tests were made with the idea of securing more than the transmission coefficient. Information was desired as to the time element and to the effect of placing the

radiator at right angles to the wall and parallel to the wall. The cast iron radiator and the pressed steel radiator were tested under the same conditions.

Mr. Newport: I would like to inquire as to the method of the removal of air from those radiators. It seems that the B.t.u. is pretty low for a 2-column cast iron radiator.

Mr. Verner: They experienced some difficulty in removing all the air from the radiators due to the position of the air valves. The radiators when first installed had air valves located near the top and it was difficult to get rid of the air in a short time. The valves were later placed near the bottom and a small amount of steam was allowed to escape. Much better results were then secured.

Mr. Busey: I had occasion to run a good many tests on radiators to check radiation, and I found a great deal of trouble in getting the air out of them. I tried different valves, tried blowing them out for quite a while, and finally I decided, to get uniform results, I would have to get an air valve on every loop and blow them out thoroughly. The results would be at times ragged. The only excuse I could find for it was air in some of the sections that was not properly blown out.

Mr. Newport: I believe that Professor Allen had quite some difficulty in his tests with the removal of the air, and if I remember rightly he could not depend upon the automatic air valve.

Mr. Verner: The radiators when first installed had air valves located at the top and there was some difficulty in getting rid of the air in a short time. To correct this the air valves were placed near the bottom which made a better arrangement. A slight amount of steam was allowed to escape from the air valves continuously so as to be sure that no air was left in the radiator.

Mr. Donnelly: I notice in the cut that one of these radiators is of the hot water type and the other steam. If I remember correctly the steel radiator now is steam type and not the hot water type. There are two considerations in regard to air in the radiator. If these radiators are used or if the coefficients are to be used in ordinary systems where the little nickel-plated air valves are used on the radiator, they should be so tested. The difficulty here is that all the air was removed from the inside of the radiator and the radiator was completely full of steam. Professor Allen has apparently assumed that each radia-

tor was completely filled with steam. I do not think that assumption was warranted. I think some method should be taken to prove that there was no air in the radiators. So far as I know, when I was on the Committee on Tests about two years ago, we could not be sure that all the air was out of the radiators. We found and reported to the Society that one of the best methods of testing whether the air was all out of the radiator was the temperature of the return water. A collection in the radiator of one or two per cent. of air would drop the temperature of the water some ten or fifteen degrees. If I remember rightly we filled the radiator with water. That probably answers some of Mr. Newport's questions.

CCCXXXV

HEATING AND VENTILATING PRACTICE IN SWEDEN.

BY HUGO THEORELL

In the following short paper on the status of heating practice in Sweden at the present time, it might be mentioned in advance that, because our climatic conditions and modes of living are similar to those of the Germans, the practice as regards the design of heating and ventilating plants has developed along the same lines and in accordance with the same requirements and methods of installation as in Germany. It may be that in small details there is a difference, but in the aggregate that which is essentially German is scarcely changed here.

The lowest temperature in Southern and Central Sweden is usually about 20 deg. Celsius, while in the northern part it is about 35 deg. Celsius. Heating arrangements must contemplate a temperature range of 40 deg. to 55 deg. Celsius. The temperature of the winter months averages about 0 deg. Celsius, except in the northern portion where it is appreciably lower.

The heating season lasts 7 to 10 months according to geographical location. In general it is aimed in the construction to maintain the following room temperatures: Dwellings, offices, etc., + 18 deg. Celsius: schoolrooms, a little lower, sick rooms, + 20 deg. Celsius.

The necessity for ventilating is essentially less in Sweden than in the United States as the climate does not so extensively demand it. One figures for schools an average of 25 c. m. of air per person per hour, and for hospitals 60 to 100 c. m. Legal provisions relating to changes of air cover factory conditions which, however, are not important.

Arrangements for introducing moisture into the air are seldom found except in certain factories. Apparatus for filtering the air to clean it for ventilation is required only in exceptional cases, since the air in general is tolerably clean. The filters which, however, sometimes find application, consist of wool

or wadding stretched in frames. Apparatus to ozonize the air has lately been used, though seldom, and the results in certain cases have been advantageous.

Refrigerating or cooling plants are used only for special purposes as, for example, in slaughter houses. The cooling of the air for rooms in dwellings, etc., is unnecessary here as the temperature in summer seldom goes above 25 deg. Celsius or perhaps at times 30 deg. In large dwellings now and then, however, arrangements for cooling are installed, some of a mechanical nature and some by cold-producing mixtures.

Of the existing heating systems the following may be mentioned:

Hot air heating, which formerly was used considerably, is now found only in small churches and halls which do not require to be heated continuously and where the value depends on simplicity.

Low pressure steam heating is applied mostly in schools, churches, hospitals, small factories, etc. The boiler plant consists usually of cast iron boilers with automatic regulators and suitable for continuous combustion so that they can be of service at least eight hours. The working pressure varies from 0.05 to 0.1 atmosphere. The highest pressure which can be reached is 0.15 to 0.50 atmosphere according to the construction of the safety apparatus which consists of a U-formed water gauge. Safety valves are never used for low pressure boilers. The pipes for steam and condensed water are always separated thus forming a two-pipe system. The passages for conducting the condensing pipes are used for admitting and withdrawing the air and are extended high over the roof by means of which in exceptional cases ventilating air is available for the radiators. In the steam conduits of the radiators regulating valves with double shut-off arrangements or dampers are built. When the plant is put in operation these dampers are so set that even when the regulating valves are wide open no steam can pass through the radiators into the condensing system which is of importance in this open system. The valves are besides equipped with graduated scales so that the position of the valve can be constantly read.

Heating with live steam reduced in pressure from large steam plants is found in large complex constructions. The arrangements are for the most part like those for low pressure steam.

Hot water heating is very much preferred and is used exten-

sively in buildings where the heat requirements change but little, and where large artificial ventilating apparatus is not necessary as for example in dwellings, offices, museums, and such. The piping is arranged according to the two-pipe system. On the radiators are regulating valves for the entrance of the water and for the return there are screws with shutting-off devices. The valves are mostly provided with double closing arrangements. The radiators and pipes are designed for a maximum water temperature of 80 deg. Celsius and a temperature difference in the entrance and return pipes of 20 deg. Celsius.

Hot water heating under pressure from pumps has in recent years been widely installed for large building construction. The heating of the water takes place directly in hot water boilers or indirectly with steam in preheaters. The circulating pumps are steam or electric propelled centrifugal pumps.

Central station heating plants are not much in vogue although it has been under consideration. In the large cities the regulations of the authorities regarding pipe laying in the streets are a hindrance to this.

Electric heating finds application thus far only to the smaller offices or bureaus and churches which are situated in the vicinity of electric water power stations. The price per k.w. is in such cases about 2 öre (one-half cent), or a certain rate per year is charged.

Boilers for small plants are of cast iron of American, German and Swedish manufacture and constructed for burning coke or anthracite coal. In the large plants boilers of malleable iron for firing with coal are used. Wood is rarely used as a fuel. The heating apparatus consists almost entirely of the radiators of American pattern, made, however, mostly in Sweden. They are usually placed in the window bays without any covering. Only in the finer establishments with expensive furnishings and decorations are fenders of bronze or similar material placed before the radiators.

Ventilating Arrangements. In dwellings and other buildings which do not require extensive ventilation fresh air is led into the various rooms through fresh air dampers located in the outer walls. These dampers are built either into the ceilings or behind the radiators. Where extensive ventilation is demanded the air is warmed in warming chambers and by means of radiating ventilators it is forced into the different rooms by direct connected electric motors through air ducts built of gal-

vanized iron in the walls. In this respect as in many others we are learning more and more from the United States. For conducting away the air, ducts from all the rooms are led high over the roof. Special suction ventilators for removing the air are seldom installed unless simply in localities where bad air exists.

To compute the heat loss, heating surface of radiators and boilers, conducting pipes, etc., the German system is used. Native literature on this subject is very scarce. Among the German authors Professor Rietschel stands foremost in the realm of heat treatise.

The working out of detailed plans with a description and specifications for heating and ventilating apparatus is entrusted to consulting engineers almost always for large projects and very often for smaller ones, but they do not themselves carry out the plans. Bids on these are then asked for from installing firms either through advertisements or three or four firms are invited to present bids. Of these bids the lowest usually but not always is selected for the project. The arrangements are then placed in the control of the constructor. To carry to completion heating plans no special approval from the authorities is necessary which, however, is necessary in gas and water installations which are to be united to the gas and water works.

In conclusion it should be emphasized that faith in central heating is rapidly rising and that it is now the exception when houses are erected without such provisions.

CCCXXXVI

LIFE OF BUILDING POWER PLANTS

BY C. M. RIPLEY*

In April, 1913, Mr. W. H. Chesebrough, President of the Alliance Realty Co., asked the author the following question:—"How long can a private electric plant be run before it has to be replaced?" It was an original and searching question and one which sought for *facts*. Others have asked frequently how much depreciation should be charged off on engineering installations of various kinds. This question desired no one's conclusions—merely the facts in the case.

The electrical profession is yet in its infancy. Up to the present time we have had very little data on the subject of the life of electric plants in buildings. It has been the custom of many engineers and architects to assume a 5 per cent. depreciation as the proper annual charge-off on such installations. It has been the opinion of many eminent men who have examined the facts developed by Mr. Chesebrough's question, that 5 per cent. depreciation has been used temporarily in the absence of better data.

OLDEST PRIVATE ELECTRIC PLANT IN NEW YORK

It is an interesting fact that the oldest plant for generating electricity in a building in New York City, was installed and in operation less than four years after Thos. A. Edison announced his discovery of the incandescent electric light in October 1879. In 1883 Mr. George B. Post let the contract for a private electric plant in the Mills Building, opposite the Stock Exchange on Broad Street, New York City. This was before there were trolley cars in New York City. This plant is still in daily operation. It seems miraculous that the fifteenth and nineteenth dynamos made by Thomas Edison have run every day for over 31 years and are still in a serviceable condition. Not only are the same dynamos in operation but the original engines installed at the same time by the New York Safety Steam Engine Co., long since out of business, are the sole means of driving the dynamos. A year later another unit of exactly

*Non-member

the same type and capacity was added. Mr. A. M. Bogart, the chief engineer of the building, states that these machines operate daily until the load becomes too large for them to handle it. This time is between 4:00 and 7:00 a. m. every day.

As an example of how the erection of high buildings in the neighborhood has increased the need of electric light in the Mills Building, it should be noted that the owners installed at later dates, a 75, a 100 and a 160 k.w. dynamo to carry the increase thus made necessary. The three original dynamos were each of 25 k.w. capacity, showing that the new equipment was used to supplement, and not replace the older and smaller apparatus. Regulation of the height of buildings will make unnecessary such additions to future electric plants.

Mr. Bogart calls attention to the further fact that even though these engines and dynamos may be assumed to have a lower efficiency than more modern apparatus, he must heat the building during a large part of the year; thus he explains the fact that these engines are used. Had machines of higher efficiency been installed, the exhaust steam from them would not have been sufficient to heat the building and live steam from the boilers would have to be used in larger quantities than is required even now on cold days to supplement the exhaust from these old engines.

OTHER PLANTS OF HISTORICAL INTEREST IN NEW YORK

On the basis of the Certified Public Accountant's Report, quoted later it will be seen that in the following plants the annual depreciation has been less than 2 per cent.

In the Dakota Apartments, H. J. Hardenbergh installed a private electric plant in 1885. Some of the same apparatus is still running every day. One direct connected unit was added afterward because of increased load due partly to the erection of large buildings on either side. This plant also supplies a dozen or so private residences on Seventy-second and Seventy-third Streets with heat and electricity. The machines were Edison dynamos also. Another plant in its twenty-ninth year of service is in the Wells Building, in which the New York Quotation Company has a private plant supplying electricity to 1200 tickers below Fulton Street. The Osborne Apartment house contains an old belted Edison dynamo held in reserve. This machine is 29 years old.

By referring to the figures quoted by the accountant it will be seen that the annual depreciation in the following plants is less than 2½ per cent.

The Evelyn Apartment house has a 25-year old plant which consists of one engine and dynamo which run every day from late afternoon till 1:30 o'clock a. m. The Bank of New York has an old outfit 25 years old, which is held as a reserve, but is run once a week to keep it in good condition. The Union Trust Co. for 25 years past has had its same engines and dynamos running, and at present they operate from 8:00 a. m. to 10:00 p. m. The Tower Building, soon to be razed, has a plant 24 years old which has the record of running as long as the building has stood.

For 24 years the electric dynamo at 79 Crosby St. has supplied electricity to the building and now supplies two other buildings. Madison Square Garden has a private plant that is now idle after working 23 years. The superintendent claims that during the past summer he has saved money by shutting down the plant in May. Those in charge say they can run the plant if they want to, as that provision was made in the electric contract. The Nevada Apartments still obtain their electricity from the old belted plant that has been under the sidewalk for 23 years. This plant has never been enlarged as the building occupies the entire flatiron block and tall buildings could not be built adjacent. The Mechanics and Metals Bank operated a plant for about 23 years and abandoned it. Shortly after, the building was torn down to make room for the new Morgan Building.

Attention might also be called to the following plants which have been in operation sufficiently long to warrant placing the annual depreciation at less than 3 per cent:

Delmonico's, also on a flatiron corner at Beaver Street, still obtain their electricity from the same old engine and dynamo that have served them for 22 years. The same is true of the Butler Bros. store on Broadway: no change in 22 years. The same is true of the United Charities Building, which also supplies next door. The Evening Mail Building has a plant now reported to be in its twentieth year of service.

The Potter Building plant has seen 19 years of service and is still running. Thus the annual depreciation of its plant is less than 3½ per cent.

Mr. Hardenbergh's Waldorf Astoria has a plant in perfect condition after 17 years, and the owners of the Bennett Building state that their plant is now in its eighteenth year. In these two the annual depreciation has therefore been less than 4 per cent.

The Sterling Building on East Seventeenth Street has had one

engine and one dynamo for seventeen years; no other. Mr. C. O. Mailloux, an electrical engineer, reports the unique and successful installation of a gas engine, dynamo and storage battery in St. Paul's Methodist Church which has run continuously for 16 years. The engine operates three days per week and the battery furnishes lights during the rest of the week. It will thus be seen that in these two buildings the annual depreciation is less than 4½ per cent.

INTERESTING BUT NOT CONCLUSIVE

The foregoing are only a few of the many plants which were inspected during the search for the oldest plant in New York. The data is interesting and historically instructive, but no logical conclusion can be drawn therefrom for the reason that the plants which were failures are not to be found. Possibly someone may say the foregoing plants were selected and are even exceptional cases. In order to answer Mr. Chesebrough's question, all the dead plants must be reported on as well as the survivors.

A HUMAN ANALOGY

If it were desired to know "The life of a man" it would require the combined records of all the insurance companies and the life work of an investigator. But it is comparatively simple to determine the life of the men in some well-known American families, as records are in existence of the lives of the members of those families.

The only records open to the investigator who included those plants which *are* running as well as those which *may* have been scrapped, are the records of the office with which he is identified. Thus all the plants "fathered" by this office of consulting engineers comprise a class in which an exhaustive investigation may be conducted with profit and which may lead to important conclusions. A personal inspection was therefore made of every private electric plant in New York City and Jersey City, which had been designed and constructed under the supervision of this certain engineering office. All plants mentioned hereinafter are therefore in either one of these two cities. The records referred to cover a period of 22 years or from 1892 until 1914 All dates and ages have been given accordingly.

The records of private electric plants to which the investigator had access, show the following now in operation, on which a 5 per cent.

depreciation appears to have proved excessive. The four following are in their

TWENTY-SECOND YEAR OF SERVICE

The New York Eye and Ear Infirmary, runs its plant 18 hours daily and the rest of the time on a storage battery. It later added to its building, and installed an additional engine and dynamo, and the storage battery. Jacob Ringle & Son use an old engine which supplies belted power as well as electricity. The Havemeyer Building, which later added a larger dynamo owing to the erection of tall buildings next door and opposite on Church Street and on Cortlandt Street, and owing also to the increased use of electricity. The New York Herald Building in which no new engines have been added as the building occupies an entire flatiron block and no building could be erected adjacent. The dynamos now in service are not the ones originally installed but the old engines are. This may be considered an exception. However, the chief engineer claims his plant is 42 years old, as with *The Herald* and *The Telegram*, both daily newspapers, it has done double duty.

Therefore it seems on the basis of the table furnished by the certified public accountant, that the foregoing plants show less than a 3 per cent. depreciation with the possible exception of *The Herald* plant. If these plants operate for another year 2½ per cent. depreciation will appear to have been proved excessive.

PLANT IN TWENTY-FIRST YEAR OF SERVICE

The Presbyterian Building has neither added to nor subtracted from its original electric plant, and since it is still operating in perfect condition a 3 per cent. depreciation has been proved excessive.

PLANTS IN TWENTIETH YEAR OF SERVICE

The St. Paul Building has made no change in its electric plant. This, according to history, was the first 25-story building ever erected. Both the manufacturer of the engines and the dynamos are long since out of business, but their product survives them.

The New York Clearing House has made no change in its electric plant. It obtained an advantageous rate for street steam and holds its boilers in reserve. Grace Chapel has run the same plant for all these years without change. The Liederkrantz Club has its original engines and dynamos. The plant runs afternoons and evenings, the storage battery serving the lights during the rest of the time. In all of the foregoing plants 3½ per cent. depreciation may be considered as excessive.

PLANTS IN NINETEENTH YEAR OF SERVICE

The American Surety Building now operates the same engines and dynamos as were originally installed. These were shut down for two years, but in 1913 were started up. The Metropolitan Building (Havemeyer Estate) and the Commercial Building (Havemeyer Estate) have been in operation without change since originally installed. The Criminal Courts Building is operating its original plant. It later added one other cheap engine and dynamo which are but little used. In the old Times Building one of the original engines and dynamos are still in service. St. Luke's Hospital operates every day between 11.00 p. m. and 8:30 a. m. its old engines and dynamos. Additions to the Hospital necessitated installation of other units. In all of these plants 3½ per cent. depreciation, to all appearances, has been proved excessive.

PLANTS IN EIGHTEENTH YEAR OF SERVICE

The Polhemus Memorial Clinic Dispensary has a plant which has been taken better care of than any of the other plants inspected in connection with compiling these data. The Mechanics Bank of Brooklyn still retains its same old apparatus, operating it daily. In these two plants 4 per cent. depreciation seems to have been proved excessive.

PLANTS IN SEVENTEENTH YEAR OF SERVICE

The Empire Building has made no changes in its electric plant since first installed. The Germania Bank Building, the smallest office building with a plant, and the smallest plant in New York City, has a plant now operating in its seventeenth year. The building is 6 stories, 60 ft. x 102 ft. with 2 electric elevators. The New York Athletic Club has still the same engines and dynamos. This plant is operated on a yearly contract covering heat and electricity. The contractor paid for 2 new boilers. In the Vincent Building, National Bank of Commerce, and O'Neill's Department Store there have been no changes in the plants. The Terrace Garden plant was in a precarious condition when inspected, owing to lack of proper maintenance. The tenant is spending close to $10,000 per year for electricity from the street, it is said, but will not appropriate half this amount for improvements. His lease will expire shortly. The Church of The Holy Trinity has made no changes in the plant serving the boys' club, gymnasium, church house, parsonage, etc.

In the foregoing plants all in their seventeenth year of service 4½ per cent. depreciation has been proved excessive.

PLANTS IN SIXTEENTH YEAR OF SERVICE

The Ormonde and Seminole apartments are operating the same equipment as originally installed. These were among the first apartments to give refrigeration service to tenants. The Sprague or Anderson Building and the Metropolitan Museum of Art are operating the original equipment. For 15 years the one engine and dynamo served the old Astor Library. When the Astor Library was removed to the New York Public Library Building the Director, the late Dr. J. S. Billings, and others in authority, voted that the old plant be carefully removed and installed ready for services in the new building. The plant, speaking sentimentally, has been pensioned as its reward for faithful service for a period of nearly 16 years. It is still capable of useful work. For experimental purposes this may be operated later or for periods of light load, or it may be sold and used elsewhere. In any case, it cannot be said that the plant is dead,—just retired,—perhaps only temporarily but certainly with credit. In the foregoing plants 4½ per cent. depreciation has apparently been proved excessive.

PLANTS IN FIFTEENTH YEAR OF SERVICE

The Navarre Hotel operates the same old apparatus and also supplies several stores next door with heat and electricity. The building at 395 Broadway still operates the plant as originally installed. The Wellington Hotel has retained its original plant and the Commercial Trust Co., Jersey City, operates its original apparatus. The plant in the New York University (Hall of Fame, etc., University Heights), consisting of but a single engine and dynamo, supplies light and power to 6 buildings, and heat to 12 buildings covering 37 acres. The plant is heavily overloaded. In these plants all doing their fifteenth year of service 5 per cent. depreciation, to all appearances, has been proved excessive.

The foregoing list of 34 private electric plants are all in operation, except the Library pensioner. This list covers every installation made in 1900 and earlier, by the office with which the author is identified. No plants installed in 1900, or before, have been scrapped, but during the current year some of these plants mentioned herein may be discontinued and sold for scrap.

Mr. Whitaker, editor of *The Journal of The American Institute of Architecture,* asked:—"Why not figure out for each of the old plants what would have been the proper rate of depreciation to have charged off from the start?" In order to carry out this important suggestion, a report was obtained from a certified public accountant, which is included here because of its brevity and clearness:—

New York City, October 30th, 1913

Mr. C. M. Ripley,
Pattison Bros., Consulting Engineers,
1182 Broadway, New York City

Dear Sirs:—

In compliance with your request, we report to you as follows:—

TIME REQUIRED FOR A SINKING FUND TO EQUAL ORIGINAL INVESTMENT

(*Sinking fund earning 4½ per cent. interest, compounded annually*)

Percentage Depreciation Charged Off Annually		Years Required to Refund Investment
1½	Between	31 and 32
2	Between	26 and 27
2½	Between	23 and 24
3	Between	20 and 21
3½	Between	18 and 19
4	Between	17 and 18
4½	Between	15 and 16
5	Between	14 and 15

It is proper and conservative to assume the above rate of interest on a sinking fund. We trust that these facts fully answer your questions. If we can be of further service to you, we await your wishes.

Yours very truly,
CERTIFIED AUDIT COMPANY OF AMERICA
(Signed) By Edward M. Hyans,
Certified Public Accountant

SUMMARY

Taking into consideration the 34 private electric plants (*installed as early as* 1900), the results stand as follows:

34 of them show less than 5 per cent. depreciation.
29 of them show less than 4½ per cent. depreciation.
17 of them show less than 4 per cent. depreciation.
16 of them show less than 3½ per cent. depreciation.
4 of them show less than 3 per cent. depreciation.

1 (*New York Herald*) plant may or may not show less than 3 per cent. depreciation, according to the way it is figured.

DISCUSSION

Professor Kent: I wish the author would add to his paper this conclusion. His facts are all right, but the conclusion which the gentleman asked for "How long can a private electric plant be run before it has to be replaced?" does not appear. If the author was making an estimate of the cost of electric service for an owner who was planning to build, he should say whether he would advise putting in an isolated plant, or taking service from outside, and in figuring on insulated plants, how much depreciation should be allowed, whether two and a half, or three per cent., or three and a half, or what figure. I would like the gentleman to answer that question if he can now—"How much depreciation would he allow?"

Mr. Ripley: I feel I am too young to draw conclusions. I have supplied you only with facts.

Mr. W. F. Verner: This paper is very interesting to me, as that has been one of the problems I have had before me for the last year—what is the proper depreciation?

As stated by the author, it has been the custom of every engineer and architect to assume five per cent. or more for depreciation. Ten per cent. is quite a common figure for plants operating continuously when including insurance and taxes, which amounts to about three per cent. Five per cent. depreciation in my mind means a life of twenty years for the article in question. The fund necessary to set aside each year, of course, depends on the life, and the interest returned upon the depreciation fund.

Now, in connection with that, I would like to ask Mr. Ripley if the term "depreciation" as used in the table of results, refers to the fund to be set aside annually, or the amounts of per cent., the plant has used up in its life; that is, in using the term five per cent. depreciation in the last table of results, do you mean that the plant will live twenty years; or do you mean that you must set aside a fund of five per cent., which will draw interest, and at the end of twenty years, will give a fund, with which to replace the plant?

Now, five per cent. depreciation in my mind means a twenty year life. That is something different than a fund that I must set aside, because I may consider that fund as you have, with three or four or two per cent., or whatever it may draw. I think that most architects and engineers, when they say five per cent., mean a twenty year life, not the fund set aside.

Mr. Reginald P. Bolton: Mr. Chairman, perhaps I can answer the last speaker's inquiry on this subject of depreciation, because I have studied it very closely. The essential error in this paper is due to the fact that the certified public accountant—as such accountants are in the habit of doing—does not explain what he is driving at. He does not tell you that this rate he gives here is a rate based upon the actual setting aside each year of the actual cash put into the sinking fund, in some form of investment, and drawing interest at the rate of four and a half per cent.

Professor Kent: That is what it says here.

Mr. Bolton: He only tells you that in this direction. He says the time required for a sinking fund, to equal an original investment, compounded annually. Now the author of this paper omits that consideration from the start, and speaks of charging off interest, which is a totally different thing. In other words, book depreciation is merely straight line depreciation. In other words, you divide the life, by the total sum that you have spent upon it, and then you decide on a percentage or the proportion of the cost which you charge off on your books, every year, against the plant.

In other words, all these plants here, no one of which—to my knowledge, and I am sure nobody else knows to the contrary—has ever set aside a dollar for an actual sinking fund, are chargeable not with the rate of depreciation based on compound interest, but with straight line depreciation, all of them must be charged in that way. I do not know one plant owner in New York City to-day although I have been preaching depreciation and sinking funds for years, that has ever set aside a dollar, either in respect of buildings, or respect to a plant; and, consequently, when the time arrives when a plant is no longer really useful to them, they have not any money to replace it; and that is why those old plants are still in existence, they cannot get another plant because they have not set aside the money to purchase it.

Now, as an illustration of that fact, you will find a number of plants running to-day which have not been removed or replaced, but which should have been replaced, and it is a very interesting fact that Professor Kent, just now, in quoting from memory the question asked here by Mr. Chesebrough, put a very different complexion upon it, and which I think was the question that Mr. Chesebrough really asked, because I am very well acquainted with him, and I know his financial ingenuity.

He said I venture to think, "How long can a private electric plant be run before it *should be* replaced," instead of "Before it *has to* be replaced."

The answer to that question, as printed in the paper, is, "Never." It does not have to be replaced, you can leave it there, if you are chump enough, for 150 years. I have seen instances of that character.

I recall in a shipyard in England, seeing an old horizontal engine, with a very old and heavy centrifugal governor, running round and round but having no connection with the valve gear. I asked the engineer why he continued to run the governor, and he said, "We have always done it, and the engine runs better with it."

As regards the actual physical life of machinery, if you come to that, you can find all around here, old machines that are running for very much longer periods than those mentioned in this paper such as the old No. 1 pumping engine, at Ridgewood which was put in in 1859, and was running up to five years ago, but look at the space it occupies; look at the coal it used; look at the uselessness of the machine, the cost of repairs and upkeep, and even so it had been almost rebuilt twice in its life.

I remember seeing one of Fairbanks' old engines, which had been running over 60 years, the main frame of which was a stone wall. There was no reason why that should not run 160 years, but nowadays, we try to keep in the march of progress and have economic machinery.

Now, Mr. Ripley has made a great deal of some of those old plants and the Mills building is one of his choicest instances. I know those engines, and they are curiosities, but that is all they are. They are running every day, or more or less every day, and will take a little load for a couple of hours; then they get so hot that they have to shut one down. The armatures are in bad shape. The commutators are bad, and in fact, no one would want to run such a machine, if he could replace it, by a reasonably inexpensive machine, which would occupy less space.

Now, take the case of another building, the Union Trust Company. They have two little machines, each of about twenty kilowatts, which I looked over yesterday. They have two generators, belt driven by simple engines, but alongside is a modern direct connected unit which is doing the real work of the building. Those old engines are occupying a space of 600 square feet, the rental value of which is worth alone $1.00 a square foot. The

old machines are really eating their heads off, or have done it within the last twelve years, in rental value alone. They should have been scrapped long ago. Machinery has no value at all, just as soon as it has reached a point where it is inefficient, and better work can be done by another appliance. A great corporation in the West, recently scrapped electric machines less than five years old, because they could not afford to keep them running, and that will be the depreciation that we will have to meet in the future, to keep machinery up-to-date and economic.

A machine's commercial value is what limits its life; not its physical life, which may run 100 years. That is what I should take to be the real essence of the series of observations in this paper. If you apply the straight line rate of depreciation to these instances, you get a totally different result from what is sought to be established.

For instance, taking up the old power plant quoted by the author, and charging a straight line rate of book depreciation, instead of a compounded sinking fund depreciation, the average runs out at 4.45 per cent. per annum. Taking the 22 instances given by the office of the engineers with whom the author is associated, on the straight line basis, the average becomes 5.63 per cent.

Nobody is going to say that many of those old plants may last very much longer, but the question is whether they have any commercial value to-day. As soon as a generator plant ceases to supply energy at a cost at which it can be bought from another source, or as soon as a steam boiler plant for the same ceases to supply steam at a cost less than the price at which it can be bought outside, it has no commercial value whatever. It is a contingency that has to be provided for, and those are the things which make investors very cautious nowadays, about the charging off sufficient depreciation.

Let me add one word more, Mr. Chairman, as to the interest that all this has to those about to own property. We are allowed to deduct from our income tax returns, a certain amount in respect of depreciation on our property. That process is going to bring this subject home to the hearts—which means the pockets—of a great many people who own real estate in this city and elsewhere.

Professor Kent: What depreciation would you allow for, that he was too young to answer?

Mr. Bolton: I am afraid I cannot give the same reply as the author, as I am old enough, but I think twenty years is too long, and I would allow no more than fifteen years.

For any method either invested or book depreciation I want to emphasize this point: The life of machines does vary physically by reason of the kind of work that they have to do, the space they occupy, and the variability of the repairs. These features should be taken into consideration; but why I say that twenty years is too long a life to allow is because I am looking specially at the commercial depreciation, and the value of the machine as an apparatus in keeping up-to-date; just as a man has to keep up-to-date.

Mr. Verner: I would like to speak relative to the statement given in the second paragraph of the first page of Mr. Ripley's paper: "It has been the custom of many engineers and architects to assume a five per cent. depreciation as the proper annual charge-off on such installations. It has been the opinion of eminent men who have examined the facts developed by Mr. Chesebrough's question, that five per cent. depreciation has been used temporarily in the absence of better data." That is a pretty strong statement to make, and from the points developed this morning, I do not know whether I would like to see that accepted as true.

Mr. Ripley: Perhaps some one of the eminent men, who made that statement, might answer you.

I understand that when the Equitable Building was passing on the question of whether they should make or buy their electricity, that they charged either two and a half or three per cent., and I know the head of our firm, who is now figuring on a large plant, put down three per cent. as the depreciation, and I would like to make one more observation as to something I found. It was called to my attention that a report was made that the plant in the American Theatre on Eighth Avenue and 42nd Street had been discontinued, and when I called to find if the report was true, I found the engines were running, and the chief engineer said, "Oh yes, every fall for years, when we turn on the steam, we start up the engines, why not," showing in a few words what a great many people believe to be the truth, that is, the steam comes from the boiler toward the radiator and roof, it might as well pass through an engine, or put it in another way, the steam goes to the radiator from the boiler via an engine. That is true in a theatre in the winter, and has been proved so for years. The same policy by the way, is adopted in Lord & Taylor's store, and a big store on Eighth Avenue. If that steam is there during the winter, in that type of building, or in a large hotel, or industrial concern, using heat 365 days in the year, and in

many cases 24 hours a day, the chief engineer would be right in my opinion in saying "As long as we leave the steam turned on, we leave the engines running."

In a conversation in June or July with Mr. Robert Gair, who owns a factory consisting of a group of buildings, used for the purpose of making paper boxes and paper specialties, he said: "My fuel bill is more on holidays than it is on cold weather days. It is peculiar but when the engines are in operation making electricity for the factory, I burn less coal than when my factory is idle, and I am simply keeping it warm." He further said: "I would not consider a proposition to purchase my electricity for one cent per kilowatt hour, and I doubt if I would consider accepting three-quarters of a cent rate from the street."

That is very much in line with what Mr. Weinshank, Mr. Kimball and others discussed at a previous meeting of this Society, and which was quoted in the Heating & Ventilating Magazine for March, 1910. Several examples were given by Professor Kent, by Mr. Kimball, by Mr. F. H. Stevens, by Mr. Edward K. Moore, and by Mr. Theodore Weinshank, where that peculiar relationship had been found.

The Chairman: Is there no further discussion on this paper?

Mr. Bolton: Yes, I would like to say a word as to the engineer's inquiry: "Why not?" by saying "Why should you run an engine, and use its useful existence up for the purpose of passing steam through it to do heating, which you can do just as well by sending it through on a straight circuit; why should you generate steam and condense part of it, before it gets to the engine and run feed pumps with other parts of it, and use that steam in other auxiliary appliances connected with it, all for the purpose of using the balance of the heat from the engine. The used steam is not worth as much for heating purposes as direct steam," but this subject is foreign to the matter of this paper, which really deals with the question of depreciation but if you use an engine needlessly, you depreciate it that much quicker.

CCCXXXVII

EFFECT OF TIME IN DETERMINING RADIATION

BY JOHN R. ALLEN

The rules usually used in determining the amount of radiation used to heat a building assume that the building is not allowed to cool during the heating season. If there was installed in a room just sufficient radiation to supply the wall, window and diffusion losses and the building should be allowed to cool, then it would take an indefinite amount of time to warm the building. The necessity of warming the building when it has once been allowed to cool is allowed for by most engineers by adding a certain percentage to the radiation determined, assuming the building to be continuously warm. In this paper I propose to show that an expression can be developed which will serve to calculate approximately the amount of radiation necessary to warm a building in a given length of time and also the time required to cool a building to a certain temperature.

Ordinarily it would not be necessary to use such an expression for buildings such as residences, stores and hotels. There is another class of buildings such as schools, auditoriums, churches and factories, which are at times intermittently heated and to which these expressions would apply. This is particularly true with large monumental buildings such as cathedrals where the effects of the heat stored in the walls is very appreciable. The heat stored in structures like the great cathedrals of Europe is of such an amount that no heating system is necessary. Take, for example, the great Mosque of St. Sophie, which is located in a climate where the temperature at times is as low as 20 deg. above zero. The heat stored in the heavy walls of this building during the summer is sufficient to keep it warm throughout the winter season.

The effect of the walls of the structure on the heating of a building involves different calculations and a new set of conditions from those usually assumed. There are four principal factors: 1, the heat required to warm the exterior walls; 2, the heat required to

warm the interior structure such as windows, walls, floors and furnishings; 3, the heat required to warm the air in the room; and, 4, the heat to take care of the heat losses through walls and windows, which will include diffusion, floor and ceiling losses. In order to derive an expression for these terms, let us assume the following notations:

t_1 = the temperature desired in the rooms
t_o = the temperature outside the building
t_a = the temperature of the building when cold
t_w = the temperature of the inside of the outside walls when the building is cold
t^2_w = the temperature of the inside of the outside walls when the building is warmed
t^3_w = the temperature of the outside of the outside walls when the building is cold
t^4_w = the temperature of the outside of the outside walls when the building is warm
S_1 = specific heat of air
S_2 = specific heat of stone
S_3 = specific heat of wood
S_4 = specific heat of plaster
W = wall surface, sq. ft.
W_1 = weight of air per cu. ft.
W_2 = Total weight of stone
W_3 = Total weight of wood
W_4 = Total weight of plaster
W_e = Equivalent weight in stone for exterior building structure
W_p = Equivalent weight of plaster for interior building structure
G = Glass surface
G_e = Equivalent glass surface
n = Number air changes by diffusion
C = Cubic contents of the room
K_w = Coefficient of heat transmission for walls
K_g = Coefficient of heat transmission for glass
K_c = Coefficient of heat transmission for ceiling
K_f = Coefficient of heat transmission for floors

Then by the ordinary rule,—

(1) The heat loss per average hour from the room =

$$(K_wW + K_gG)\left(\frac{t_1 + t_a}{2} - t_o\right)$$

Reducing W surface to equivalent glass, $G_e = \frac{K_wW}{K_g}$

and total equivalent glass $G_e = G + G_e$ and expression (1) becomes

$$(2) \quad K_gG_e\left(\frac{t_1 + t_a}{2} - t_o\right)$$

The heat required per average hour to take care of diffusion would be equal to

$$(3)\quad S_1 W_1 nC\left(\frac{t_1 + t_a}{2} - t_o\right)$$

Combining expressions (2) and (3) would give the total heat loss per average hour from the building

$$(4)\quad (S_1 W_1 nC + G_e)\left(\frac{t_1 + t_a}{2} - t_o\right)$$

The building structure may involve a good many different materials and to avoid a very complicated expression, it is better to reduce them all to the equivalent weight in one material. The equivalent weights would be proportional to their relative specific heats, as for example, if a building is composed of wood and stone.

$$W_e = W_2 + \frac{W_3 S_3}{S_2}$$

If there are more materials, each material would add another term to this expression.

The heat required to warm the outside walls would be

$$(5)\quad S_2 W_e\left(\frac{t^2_w + t^3_w}{2} - \frac{t_w + t^1_w}{2}\right)$$

The heat required to warm the inside walls, furnishings and floors not transmitting heat would be, reducing their weight to equivalent weight in plaster W_p.

$$(6)\quad S_4 W_p (t_1 - t_a)$$

The heat required to heat the air in the room would be

$$(7)\quad S_1 W_1 C (t_1 - t_a)$$

The total heat to warm the building would be the sum of equations (4), (5), (6) and (7). This expression becomes

$$(8)\quad (S_1 W_1 nC + G_e)\left(\frac{t_1 + t_a}{2} - t_o\right) + S_2 W_e\left(\frac{t^2_w + t^3_w}{2} - \frac{t_w + t^1_w}{2}\right) + S_4 W_p (t_1 - t_a) + S_1 W_1 C (t_1 - t_a)$$

This expression represents the total heat to warm the building in one hour.

If, however, the building is to be warmed in a certain number of hours h, then expression (8) becomes

$$(S_1 W_1 nC + G_e)\left(\frac{t_1 + t_a}{2} - t_o\right) + \frac{S_2 W_e}{h}\left(\frac{t^2_w + t^3_w}{2} - \frac{t_w + t^1}{2}\right) +$$

$$\frac{S_4 W_p}{h}(t_1 - t_a) + \frac{S_1 W_1 C}{h}(t_1 - t_a)$$

If the building is allowed to cool after having been heated, then the heat loss (the first term in this expression). may be equated to the remaining terms that will represent the heat given up by the building structure and we have

$$(S_1 W_1 nC + G_e)\left(\frac{t_1 + t_a}{2} - t_o\right) = \frac{S_2 W_e}{h}\left(\frac{t^2_w + t^3_w}{2} - \frac{t_w + t^1_w}{2}\right)$$

$$+ \left(\frac{t_1 - t_a}{h}\right)\left(\frac{S_4 W_p}{} + S_1 W_1 C\right)$$

Solving for h

$$(9)\ h = \frac{S_2 W_e\left(\frac{t^2_w + t^3_w}{2} - \frac{t_w + t^1_w}{2}\right) + (t_1 - t_a)(S_4 W_p + S_1 W_1 C)}{(S_1 W_1 nC + G_e)\left(\frac{t_1 + t_a}{2} - t_o\right)}$$

Assuming that a building is supplied with an amount of heat, H, per hour, then,

$$H = (S_1 W_1 nC + G_e)\left(\frac{t_1 + t_a}{2} - t_o\right) + \frac{S_2 W_e}{h}\left(\frac{t^2_w + t^3_w}{2} - \frac{t_w + t^1_w}{2}\right)$$

$$+ (S_4 W_p + S_1 W_1 C)\left(\frac{t_1 - t_a}{h}\right)$$

$$(10)\ h = \frac{S_2 W_e\left(\frac{t^2_w + t^3_w}{2} - \frac{t_w + t^1_w}{2}\right) + (t_1 - t_a)(S_4 W_p + S_1 W_1 C)}{H - (S_1 W_1 nC + G_e)\left(\frac{t_1 + t_a}{2} - t_o\right)}$$

This expression represents the number of hours required to heat the building when it is supplied with H B. t. u. per hour.

In order that these expressions may be more easily applied, let us assume some reasonable values for the quantities in these equations, as follows:

$t_o = 0$
$t^1 = 70°$
$t_a = 50°$
$S_1 = 0.2375$
$W_1 = 0.077$

If the temperature of the inside and outside air is given then by Rietschel's rule, the temperature of the inside and outside of the wall may be obtained. Let t be the difference in temperature between the wall and the surrounding air, and l the thickness of the wall in feet. Then $t = 16.2 - 4$ and assuming a wall 2 ft. thick, $t = 16.2 - 8 = 8.2$

hence $50 - t = 8.2$ or $t_w = 41.8$

$70 - t = 8.2$ or $t^2_w = 61.8$

and by the same expression

$$t^1_w = 8.2 \text{ and } t^3_w = 8.2$$

Substituting the above values in equation (9) we get, assuming $n = 1$

$$h = \frac{10\, S_2\, W_e + 20\, (S_4\, W_p + S_1\, W_1\, C)}{1.1C + 60\, G_e}$$

and expression (10) becomes

$$h = \frac{10\, S_2\, W_e + 20\, (S_4\, W_p + S_1\, W_1\, C)}{H - (1.1C + 60\, G_e)}$$

and the expression for large H is

$$H = 1.1C + 60\, G_e + \frac{10\, S_2\, W_e}{h} + \frac{20\, (S_4\, W_p + S_1\, W_1\, C)}{h}$$

The actual effect of the walls on the amount of radiation can best be shown by applying this expression to an actual case in which

W_e = 5,686,600 lb.
G_e = 7608 sq. ft.
C = 400,000 cu. ft.
S_2 = 0.21
S_4 = 0.20
W = 10000 sq. ft.
G = 2000 sq. ft.
W_p = 200,000 lb.

then the number of hours required to cool the church would be

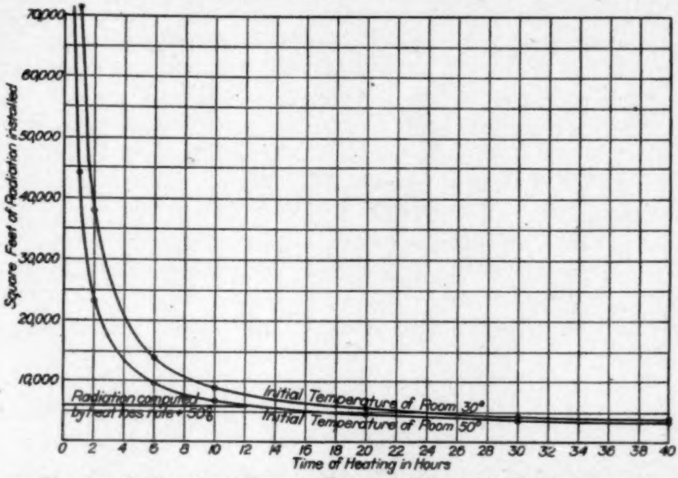
$$h = \frac{10 \times 0.21 \times 5{,}686{,}600 + 20\ (0.20 \times 200{,}000 + 0.0183 \times 400{,}000)}{1.1 \times 400{,}000 + 60 \times 7608}$$

= 14.4 hr., or the time necessary to cool the building from 70 to 50 deg.

Figured by the usual rule this building would require 4000 sq. ft. of 2-column cast-iron radiation and allowing 50 per cent. excess radiation on account of the building's being intermittently heated, the building would require 6000 sq. ft. of radiation. Allowing for average difference of temperature between room and steam, the radiator would give off 300 B. t. u. per sq. ft. per degree difference and the time required to heat the building would be

$$h = \frac{10 \times 0.21 \times 5,686,600 + 20\ (0.20 \times 200,000 + 0.0183 \times 400,000)}{1,800,000 - (440,000 + 456,500)}$$

= 14.3 hr. will be required to heat the building. If 100 per cent.



Curve Showing the Length of Time to Heat a Building with Varying Amounts of Radiation Assuming the Room to be Heated from Different Initial Temperatures to 70 deg.

excess radiation had been allowed to provide for intermittent heating, then the building would have had 8000 sq. ft. of radiation.

$$h = \frac{12,887,000}{2,400,000 - 896,500} = 8.6 \text{ hr.}$$

The effect of increasing the amount of radiation upon the rapidity of heating is shown best in Chart. The curve rises more and more rapidly as time of heating is diminished and the point where this rapid rise commences is about 12 hr. In a building of this character to attempt to heat the building under ordinary conditions in a short time (anything less than 12 hr.) means the installation of a very expensive plant. Our ordinary assumption of an additional 50 per cent. added to the radiation gives the time of heating as 14 hr. which, as can be seen, is a perfectly rational assumption. By means of the equations given it is possible to determine for a given building whether it is more economical to heat a building continuously or to allow the building to cool off and be reheated each time it is to be used.

DISCUSSION

Professor Kent: Mr. President, I think Professor Allen's study is an effort in the right direction, and his conclusions gen-

erally are reasonably correct; that is, that the time to heat the building under ordinary conditions, in a short time, say anything less than twelve hours, means the installation of a very expensive plant; but I think that his mathematical calculations are incomplete, in that they do not take into consideration all of the conditions.

He mentions four principal factors, and omits some other principal factors, such as the dampness or the amount of water absorbed by the walls, and the effect of the wind out of doors, which will certainly have a great deal to do with the time in which a cold building can be heated.

I do not think that any mathematical calculation to-day will give us the factors needed to make the equations correct, until we have some experimental work on the amount of heat required to heat a certain building, under all the different conditions of weather, including rain, ice, snow, and wind.

Mr. Hart: I do not know whether I understand this correctly, but I think this chart is based on the maximum conditions; in other words, assuming that it took 100 per cent. of radiation to warm a building when the outside temperature was ten degrees below zero, it would take this additional amount of radiation to warm the building up in a given time under average working conditions; we put in radiation sufficient to heat the building under maximum conditions, and it is only once or twice in a whole season that we are called upon to heat up a building under those unusual conditions, and in case we are required to heat up a building which is ten degrees below zero, why, they would be willing to devote a greater number of hours to that particular time. The average condition would be that we can heat an ordinary cold building up to normal temperature under the methods implied, without allowing any additional radiation, because our average outside conditions are about half of the maximum.

Mr. Donnelly: Mr. President, I remember when I first began looking up this subject, six or eight years ago, and mentioning it to Mr. Macon, at which time he had written an article, I think it was one of his maiden efforts on the subject. At that time he said that too much must not be expected from calculations and observations. However, for a number of years I have been seeking and recording these facts in buildings.

I read a paper on this subject two years ago, and gave the results of these recording thermometers. After all the recording thermometer is pretty nearly accurate, and perhaps a little better

than the differential calculus. I say that, because I am afraid I cannot use the differential calculus, and I can use a recording thermometer. I have two or three recording thermometers, and I have railroad friends who lend me others at the present time, I know of a railroad that has recording thermometers from which it makes regular observations. I have lent them mine for making observations in station, buildings and roundhouses.

I want to refer to some of the different conditions mentioned in the paper. I have had a recording thermometer in the building of the Corbin Screw Corporation, in New Brighton, Conn., it has an enormous amount of steel wire all through its buildings, and the thermometer shows the cooling of such buildings is very slow, on account of the quantity of heat absorbed by the contents. The Bliss Building in Brooklyn, where they manufacture very heavy machinery and have thousands of tons of cast iron always on their floors in process of manufacture the heating and cooling of which is a very important factor to consider.

In one of the buildings of the Corbin Screw Corporation, they have a rule such as I mentioned in my paper, of leaving the building to cool to 50 degrees. The watchman at night, or Sundays, or holidays, or the engineer on duty watches the building, and when it gets to 50 degrees, he turns on live steam and heats it up to 60 degrees. He shuts it off again, and when it gets to 50, repeats the operation, and I think some of those jobs that are referred to such an operation was repeated twice from Saturday to Monday.

I would like to see this subject continued and investigated still further. After steam is turned on in a heating plant it requires an appreciable amount of time to warm the coils and radiators. If a short time is to intervene, the bringing of the apparatus itself up to temperature requires all the way from one-half hour to an hour and a half.

This subject I believe should be given for investigation to a committee on tests. Recording thermometers do not cost much, and we have a great many observers who can use them. I have always had a notion I would like to put a number of recording thermometers in a factory or an isolated house, unoccupied, and let them go through a zero spell of weather. The temperature inside the house would be above the outside temperature through the night. The temperature inside the house would be less than the outside temperature during the day.

There are a number of other problems which could be profitably investigated in a similar way. I have been always interested in the time element, and I am glad to see that we are getting papers that consider it.

Mr. Bolton: Mr. Donnelly's suggestion is interesting, but if the window shades are down, and the sun does not get into the house, the calculations might be disturbed by the added heat of the sun, which is an element to be considered in the cost of heating buildings in New York City.

I am plotting the results of the actual condensation in a group of buildings against the curve of percentages of direct sunlight during the same period; I think we shall find a relation between the amount of steam, not only relative to the air temperature, but to the amount of sunlight during the daytime.

As regards the heating of institutional buildings, I never had any experience with Mohammedans such as our late President seems to have had, and I do not know to what degree the fervor of the worshippers inside of a mosque may aid the building in retaining its original heat, but the audience in all such buildings has a perceptible effect on heating which is another subject to which we might devote some investigation with profit.

I agree with Professor Kent in saying that this paper lacks consideration in one or two important features.

Leakage is one of very great importance, especially in this locality, where our windows are not guarded as they are in the west, with an additional sash in wintry weather. Our construction under the present conditions of steel frame and steel incased windows, is made in a manner to admit considerable leakage, rather than to exclude it.

A study of this kind will become of great use in deciding for us, by a method of calculation, whether we should or should not allow a building to cool off during the night. It is a practical question we are all up against.

I find the practice is establishing itself from a practical point of view of shutting up buildings of the nature of office or loft buildings, as quickly as possible, and then closing down about one-half of the radiation, and allowing the building to simmer, as it were, through the night, and then bring it up to the required temperature in the morning.

Now, some buildings cool off more than others do, but about one-half of the radiation seems to be the general idea of the night requirements except in most extreme weather.

Speaking to a contractor who was running the heating of a building by contract, and therefore, interested in saving fuel, I found that he had found it worth while to have a man go through a building every evening, after the tenants left, and carefully shut down what he considered unnecessary radiation. He has saved a substantial amount of fuel by that process.

I had an experience in a church of the nature described in the paper, in which an ample amount of heating service had been installed for heating the building in zero weather. The process that was followed in heating the building was to let it cool down during the week, when there was no particular use for the building, and then, they went in about six o'clock on Sunday morning, and tried to warm the building up for use. It must be stated that it was not a Mohammedan institution, which may account for part of the difficulty.

Mr. Davis: On the question of leakage, about four years ago, an estate in Philadelphia built, I think, something like 400 houses in South Philadelphia for rental, and they were heated from a Central Heating plant and they had some trouble with the heating. At the start they had a plant that was designed to be more than sufficient to heat the houses but it would not take care of the peak load.

They applied the window leakage treatment to the buildings and the results were more than they expected. I was asked to see if I could find out definitely just what the difference was.

I went to Philadelphia and spent 10 days waiting for a windy day, but I do not think the wind blew more than four miles an hour during the daytime while I was there. It would blow at night, and calm down in the morning, so finally we made our tests when the outside wind velocity varied according to the weather bureau, from one and a half to two miles an hour. We found that in two houses, one where the leakage was prevented, and in another, where no attempt was made to control the leakage, that there was approximately 28 per cent. difference in the heat demand between the houses and the house that was unprotected, and they had the benefit of full exposure to the sun which was not taken into consideration. That experience bears out Mr. Bolton's idea, that leakage does enter to a large extent in the time element of getting a house warmed up to a proper temperature.

There is one point that I do not think has been brought out clearly, that is the heating effect of the radiation at the beginning, where your temperature difference between the air in the

room and the temperature of the heating medium is greater. My experience has been that the raise in temperature is rather more rapid at the beginning than it is after the room is up to, say, 56 or 60 degrees.

Professor Kent: I am thoroughly in accord with Mr. Donnelly. I am glad to agree with him on the use of recording thermometers, rather than on differential calculus, and I will put on the board a sketch of something that I hope he will be able to do some day. It is to build a structure of brick, or concrete, on the roof of some building, say, six feet in each dimension, with sixteen inch walls and to put in five or six separate radiators, each with the same amount of piping, and discharging into a tank which will measure the condensation. One night open one valve, and start one radiator going, and next morning the registering thermometer in the room will show what has happened during the night in regard to the temperature in the room, and another thermometer outside of the room will show the range of outside temperature. The weather reports will give the velocity and direction of the wind, and a registering water meter the record of the condensation, so that we will have a record of all these variable factors that enter into the heating of the room. Sometimes the test will be made in cold dry weather, and in other times cold wet weather, and during winter the number of radiators in service can be changed. Thus taking the records every day, we will obtain data from which a valuable paper to the Society may be written on the effect of different conditions of weather on the heating of a room exposed on four sides and the roof.

Mr. Bolton: You need not go to that trouble. With some, you can do it with electric heating. One of our good friends tried an experiment on the roof of a West Street building for some months, experimenting with a window in a small chamber, and got very interesting results from it.

Mr. Hart: I think that by the time they have got through making a series of tests with this particular building—or coop you might call it—with a sixteen inch wall of concrete, you would have found out one point, and that is the loss of heat through that particular kind of a wall, but in actual practice, we have a great many kinds of walls. We have a number of kinds of windows of different construction.

Mr. Bolton: This is only a beginning.

Mr. Hart: I wanted to emphasize that you would not have

gotten very far, and you would have to build a great many coops before you could arrive where you have anything of much value.

Mr. H. J. Barron: I just want to get on the record a little fact that came to my mind last night, in conversation with Professor Verner, he will correct me if I am not quite right. By the conversation, the impression I got was, that our records as published, from the beginning, in the discussions in the Society, and the various papers, they do not show properly or authoritatively or correctly, the proper method of determining the efficiency of radiation, and that our records, while they are voluminous on that subject, are not desirable from a strictly scientific standpoint. Now, to me that is a very serious subject and I think the recômmendations which have been made to the council of the Society that a committee should be organized to determine or to decide, or to formulate the exact data of radiation, and the various methods of determining its efficiency should be taken up; and also the various conditions to which radiation is applied, such as indirect and direct-indirect under various conditions. If I am wrong in the impression that I got from the Professor, I would like him to correct me, because I do not want to get any wrong impressions in our proceedings.

Mr. W. F. Verner: I did not put it quite as strong as that. A year ago last March I was detailed to make a special investigation on heating and ventilating lines, and naturally I availed myself of every opportunity to find information on that subject, and as Mr. Scott will recall, I made a special trip to New York just to view what you, in the Heating and Ventilating Society, had in your library, and I looked over the transactions. I spent several days in this building, getting all the information I could on heating and ventilation, and what I said to Mr. Barron last night was, that I did not secure such information out of the proceedings of the American Society of Heating and Ventilating Engineers, as I hoped to; that is, information that I could set down and trace to the bottom, and be sure it was exactly right. I give credit to Messrs. Carrier, Busey, Allen, and others, for the information they have put in there. It is valuable, and can be used, and it is information that we can hand down to the students, and let them build on that foundation, so that in the future they can go ahead.

This equation of Professor Allen's, is, I think, a mighty fine piece of work. It gives something to the students, giving theoretical equations, and modifies the theoretical by the results of tests.

CCCXXXVIII

THEORY AND PRACTICE OF HEATING AND VENTILATING IN FRANCE.

BY G. DEBESSON, PARIS.

The area of continental France is about one-eighteenth that of the United States, and its population according to the 1911 census was 39,601,509 inhabitants. Accordingly the industry of heating and ventilation has not attained the importance that it has in America. Moreover, our climate is rather a temperate one, with, however, wide differences between the different parts of the country, as we will summarize in the accompanying table:

The table A shows, that although the length of France may be comparatively small (about 560 miles from Dunkirk to the Spanish frontier, and 500 miles from Brest to the Vosges), we have numerous varying climates: very mild near the British Channel and the Atlantic coasts, on account of the influence of the Gulf Stream, hot on the Mediterranean coast line, cold on the high uplands of the Central Chains (Auvergne) and of the Vosges.

Heating, then, has to be considered according to the district. In general, the desired temperatures in French buildings are lower than those allowed in other countries, and in particular in the United States. The average temperatures are pointed out, together with the air required for ventilation, in table B.

No laws settle such temperatures or ventilation for public or private buildings; everywhere the usages and customs govern and ventilation is often neglected. However, the Law of June 12, 1893, supplemented by that of July 11, 1903, stipulates the minima volumes of air into works: About 250 cu. ft. per person into closed works; 350 cu. ft. per person into laboratories, wine warehouses, etc.; 350 cu. ft per person into rooms open to the public; 500 cu. ft. per person into dormitories.

The law points out numerous requirements for the ventilation of works where women and children under 18 years are employed

Climates	Principal towns	TEMPERATURE, DEG. F. — Winter: Lowest temperatures in very hard winters	Winter: Average temperatures of winter	Winter: Lowest temperatures allowed in heating estimations	Winter: Average numbers of freezing days	Summer: Highest temperatures in hottest days	Summer: Average temperatures of summer	Average temperatures of the year	Rain: Average numbers of raining days	Rain: Total annual height of rain-water in inches	Most frequent winds
N-E or Vosges climate	Epinal	— 14.8	+ 14.8	+ 5.	86	+ 98.6	+ 65.5	+ 49.3	150	29.5	E
	Nancy	— 15.	+ 15.	+ 5.	68	+ 98.6	+ 67.8	+ 49.1	150	31.5	N-E
Paris or Seine climate	Paris	— 9.4	+ 42.9	+ 23.	56	+ 102.2	+ 64.6	+ 51.2	154	20.0	W
	Lille	— 9.4	+ 38.	+ 17.5	60	+ 98.6	+ 65.4	+ 50.2	152	25.5	N-W
Britain or Armorica climate	Brest	+ 14.	+ 44.8	+ 28.5	30	+ 102.2	+ 62.	+ 53.	170	35.5	W
Gironde or Gascony climate	Nantes	+ 17.5	+ 41.	+ 28.5	30	+ 102.2	+ 68.	+ 54.8	122	28.7	
	La Rochelle	+ 17.5	+ 41.	+ 28.5	30	+ 102.2	+ 68.	+ 54.9	140	28.0	W
	Bordeaux	+ 19.5	+ 43.	+ 30.5	30	+ 86.	+ 71.	+ 56.3	150	32.3	S-W
	Arcachon	+ 23.	+ 50.	+ 32.	30	+ 104.	+ 75.2	+ 59.	110	18.5	
	Pau	+ 23.	+ 53.6	+ 32.	25	+ 104.	+ 71.6	+ 56.2	125	15.7	
Auvergne climate	Aurillac	— 14.8	+ 31.	+ 14.	90	+ 95.	+ 66.2	+ 48.8	100	27.5	Varying
	Le Tuy	— 18.8	+ 32.5	+ 14.	100	+ 95.	+ 66.2	+ 48.8	100	28.7	N
	Clermont-Terrand	— 18.8	+ 32.5	+ 14.	90	+ 95.	+ 66.2	+ 49.1	100	20.0	N-W
	Limoges	— 4.	+ 35.6	+ 17.5	70	+ 98.6	+ 68.	+ 51.8	110	37.7	
S-E or Rhone climate	Lyons	0.	+ 36.2	+ 17.5	60	+ 100.4	+ 70.	+ 53.2	110	30.6	N N-W S
Mediterranean climate	Montpellier	+ 3.	+ 42.5	+ 28.5	30	+ 104.	+ 71.6	+ 56.5	67	29.1	
	Marseille	+ 10.5	+ 43.7	+ 32.	25	+ 104.	+ 72.7	+ 57.2	55	20.0	
	Toulon	+ 17.5	+ 44.6	+ 32.	20	+ 107.6	+ 73.4	+ 58.	60	24.8	N-W
	Menton	+ 23.	+ 46.4	+ 35.6	15	+ 107.6	+ 73.4	+ 61.3	40	19.7	S-E
	Cannes	+ 23.	+ 46.4	+ 35.6	15	+ 107.6	+ 74.3	+ 61.5	40	19.7	

TABLE A

Indication of Buildings		Maxima temperatures deg. F.	Cubic feet of air changed per hour and per person
Inhabited houses	Stairs, Halls, Vestibules	57.2	425 to 700 (about once the volume of the room per hour)
	Drawing-rooms, Dining-rooms	64.4	
	Toilet-rooms	64 to 68	
	Bed-rooms	59 to 60	
Schools, Colleges	Little children	64.4	425
	Youths	60.8 to 62.6	530
	Adults (Evening schools)	60.8	880 to 1060
	Dormitories	59	1060
Hospitals	Ordinary illness	62.6	2000 to 2500
	Wounded people	64.4	3500
	Contagious	62.6	5300
	Operation rooms	68 to 77	(twice per hour)
Old people's homes, asylums		64.4	3500
Museums, public buildings		59 to 60.8	530
Churches		53.6 to 57.2	
Show-rooms, theatres, music halls		64.4 to 66.2	1060 to 1400 2100 if allowed to smoke
Barracks	Day-rooms	53.6	1060
	Dormitories	57.2	1400 to 1750
Dining-rooms of hotels, refreshment rooms (shops) (where smoking is allowed)		64.4	2100
Prisons		59	1750
Works	Spinning factories, silk-mills, printing, etc.	57.2 to 59	250
	Shops, stores, offices, open to public, etc.	62.6 to 64.4	350
	Machinists, cabinet-makers, etc.	53.6 to 57.2	350

TABLE B

and for industries where dust, vapors, smoke, etc., are produced. The law of February 15, 1902, relative to the protection of public health points out the minima capacities of living rooms (minimum height, 8½ ft.; minimum capacity, 880 cu. ft.); those of hotel sleeping-rooms (700 cu. ft. for one person, 990 for two persons, 1400 for 3 persons, etc). In theatres and music halls the only heating systems allowed are steam or hot water (maximum pressure 28½ lb. per sq. in.), furnaces being excluded. It is required they be amply ventilated, but without any volumes of air mentioned. It must be noted that our comparatively mild French climate allows frequent opening of windows, often the most common ventilation method used.

As for humidity, if we except the works where the industry necessitates a special amount, we can say that in general it is neglected in France. In towns, the large buildings which are heated by a hot-air system are often provided with arrangements for filtering and washing the air, but it is usually for the purpose of stopping the dust and rarely for humidifying, to which we do not pay sufficient attention.

PRACTICE, LITERATURE, ETC.

In general, the calculations are made only by the heating contractors, and rarely by special consulting engineers, such professional men being in very small number in France. Only the second-class contractors apply to consulting engineers. The specifications are fixed, rather poorly, by the architects, except for the Government and municipal buildings, and for hospital buildings, where special committees, unhappily composed of incompetent members, have charge. The decisions of such architects and committees are almost always influenced by the price of the installation, and it must be said that generally it is the specification with the lowest price which is preferred.

Such a practice, which the theorists in vain try to stop, and which may be excused only by the mildness of our climate, keeps the science of heating and ventilating in a stagnant state, which does not allow the science to progress as much as is desirable. For, indeed, many of the coefficients used throughout the world are derived from those fixed by French scientific men (Lavoisier, Péclet, Ser, etc.), and the German formulas of (Rietschel, Recknagel, etc.) are often derived from the French ones after experiments which proved their correctness, or which tried to make their approximation more perfect. The heating trade has prevented by its acts the progress of this science, for nowhere more than in France has it tried to keep the subject under a semblance of professional secrets; nowhere are published fewer technical papers; nowhere are printed less special books.

The French heating and ventilating literature is very poor, indeed. If we will consider but modern books we have only:

THE OLDER BOOKS

1887, Vigreux: Traité de Physique Industrielle. (Treatise on industrial natural philosophy.)

1892, Ser: Traité de Physique Industrielle. (Treatise on industrial natural philosophy.)

1896, Denfert: Fumisterie. Chauffage et Ventilation. (Fumistry. Heating and Ventilation.)

1897, Picard: Chauffage et Ventilation. (Heating and Ventilation.)

1898, Augamus: Fumisterie. Chauffage et Ventilation. (Fumistry. Heating and Ventilation.)

THE MODERN BOOKS

1906, Maubras: Traité pratique de Fumisterie, Chauffage et Ventilation. (Practical Treatise on Fumistry, Heating and Ventilation.)

1908, Deny: Chauffage et Ventilation. (Heating and Ventilation.)

1908, Debesson: Le Chauffage des Habitations. (Heating of Houses.)

1910, Debesson: Le Chauffage et la Ventilation des Bâtiments Industriels. (Heating and Ventilation in Factories.)

We can add the books translated from German, or inspired from German theories:

1910, Em. Mathieu (Belgium): Note sur le Chauffage des Bâtiments. (Notes on Heating of Buildings.)

1911, Em. Mathieu (Belgium): Agenda aide-mémoire de l'Ingénieur Sanitaire. (Memorandum-book of the Sanitary Engineer.)

1911, E. Ritt (German): Détermination des diamètres des conduites des Chauffages à vapeur et à eau chaude. (Pipe Sizes for Steam and Hot Water Heating Systems.)

1912, H. J. Klinger (German): Translated by Léon Lasson. Le Chauffage des Appartements par l'eau chaude. (Heating of Rooms by Hot Water.)

1912, Dr. H. Rietschel (German): Translated by Léon Lasson. Traité Théorique et pratique de Chauffage et Ventilation. (Theoretical and Practical Treatise on Heating and Ventilation.)

1913, E. Hausbrannd (German): (Translated by Em. Mathieu (Belgium). Séchage par l'air et par la vapeur. (Drying by air and steam.)

The technical papers of the heating trade are only two; yet we may consider they print comparatively few new articles, and most frequently publish translations of American, English and German papers, for, in a general manner, the French manufacturers never contribute to the papers the results of their work, which they consider as confidential business. The French papers are:

Chauffage et Industries Sanitaires (Heating and Sanitary Industries).—A. Nillus, editor.

Hygiène du Bâtiment et de l'Usine (Sanitation of Buildings and Manufactures).—J. Loubat, editor.

ENGINEERS AND DRAFTSMEN

There are no technical schools specially devoted to the instruction of the science of the heating and ventilating industry. The schools from which are chiefly recruited the technical engineers for all the branches of industry are:

Ecole Polytechnique.

Ecole Centrale des Arts et Manufactures.

Ecoles d'Arts et Métiers.

On leaving these schools provided with a diploma giving them the title of engineer, the students are introduced into any branch ot general industry, having only general knowledge, with no specialty. Yet such engineers with a diploma make only the minority among all the technical people in heating and ventilating firms. The others are composed of students from technical education schools, classical or even elementary schools. They endow them, however, with the title of civil engineer, for which no diploma is required. Consequently, we can say, in a general way, that almost all the technical people in firms devoted to the heating and ventilating industry are self-educated men.

Only one society of heating engineers exists in France: the "Association des Ingénieurs de Chauffage et Ventilation de France" (Association of French Heating and Ventilating Engineers), incorporated in 1908. It is composed of about 200 members, and has monthly a meeting in Paris (19 rue Blanche, the headquarters of the Society of Civil Engineers), where a member speaks on a topic selected by himself. Numbers of heating engineers are members of the Society of Civil Engineers of France, in which are rarely presented papers on heating and ventilation.

HEATING AND VENTILATION TRADE

About 4000 firms are devoted in France to heating installation, among which:

3000 have 1 or 2 engineers or draftsmen;
800 have 3 to 5 engineers or draftsmen;
100 have 5 to 10 engineers or draftsmen;
60 have 10 to 30 engineers or draftsmen;
40 have more than 30 engineers or draftsmen.

The total annual business of the heating trade may be assumed to be between 150 to 200 millions of francs ($30,000,000 to $40,000,000), by adding manufacturing, jobbing, etc. The most important firms, those which employ more than 30 engineers or draftsmen, generally manufacture themselves part of their apparatus (boilers, fans, blowers or exhausters, valves or brass-work, sheet-iron work, etc.). The others are only installers, who buy all their apparatus, either built on their own designs or commercial goods.

The most important suppliers of the heating trade are:

Compagnie Nationale des Radiateurs (Branch of American Radiator Co.) (cast-iron boilers and radiators).

Chappee & Sons, Le Mans (Cast-iron and wrought iron boilers, radiators, etc.).

Société Anonyme des Hauts-Fourneaux et Fonderies de Brousseval (Cast-iron boilers and radiators).

Compagnie Française des Chaudières Phoebus (Cast-iron boilers).

Société Métallurgique de Montbard-Aulnoye (Wrought iron soldered boilers).

Société des Chaudières Radia (Wrought iron and tube boilers).

Société Krebs et Co. (Cast-iron boilers imported from Germany).

For the fittings we are almost completely supplied by Switzerland

(Fisher fittings, GF trade-mark), also somewhat by the United States, and by Germany. For brass-work and other accessories we have very few French manufacturers; 80 per cent. at least are imported from Germany, with some from the United States and England. About 50 per cent. of the fans, blowers and exhausters are made in France; the balance are American, English, and largely German.

By reading this list it may be seen that the amount of German importation in France is quite considerable, in spite of very high customs for foreign importation. The principal reasons are the great activity of German firms, their publicity, the quickness of delivery, the custom clearing offices they have under their own charge at our frontier stations, and their ability to sell at very cheap prices either by branches established in France or directly from Germany, but free of charges and expenses to Paris, quite as if they were French firms. Another reason is that very numerous competent German engineers, working at very low salaries, are employed by French contractors, where they, of course, introduce the German methods, and even German apparatus, so finding a method of increasing their incomes by discounts.

CALCULATIONS

The designs and plans are generally executed by draftsmen under the direction of engineers. Most of the firms make all the preliminary calculations:

1.—Calculation of calories lost through the walls and by the air of ventilation.

2.—Calculation of apparatus able to supply these losses of heat.

3.—Estimation of cost (net cost).

1. *Calculating the Heat Loss.* We apply the following principle: To keep a closed room at a given temperature T, it is necessary to supply it with the number of calories equalling these which are lost through its walls and by ventilation.

$$\Sigma M = \Sigma (M_1 + M_2)$$
$$M_1 = K S (T - \theta)$$
$$M_2 = 0.307\, V\, (T - \theta)$$

ΣM is the total amount calories to supply per hour, on a regular uninterrupted supply.

M_1 is the total amount calories lost per hour through the walls.

M_2 is the total amount calories lost per hour by the ventilation.

K is a coefficient which depends upon the kind of walls and their thickness, which is to say the amount calories passing through a wall of 1 square meter surface per one centigrade degree of difference between inside temperature T of the room and outside temperature θ.

T and θ are expressed in centigrade degrees.

S is the amount square meters of the walls (ceiling, masonry, glass, etc.). (1 sq. meter = 10.76 sq. feet.)

0.307 is the amount of calories required to increase the temperature of 1 cubic meter of air 1 centigrade degree.

V is the number cubic meters of air per hour for the ventilation purpose.

The coefficients K often vary from one firm to another, but the differences are small. They are generally the numbers fixed by Péclet, modified and corrected by practice.

For walls, glass, roofs, exposed to the north, we add 2 deg. C. to the outside temperature. For the same, exposed to violent winds and rain from north and west, we increase by 20 to 50 per cent. the figures found for loss through these walls. If the heating is suspended, for example, during the night, we add some supplementary radiators, taking care to provide them with stop valves, which are closed as soon as the desired temperature is reached.

2. *Calculation of the Apparatus, with Direct Radiation.*—We more often use the Péclet and Ser coefficients, corrected by German formulas, in order to calculate the value of radiators. Most French engineers used to assume that each square meter of steam radiator transmits 800 to 850 calories, and the hot-water radiator 450 to 500 calories.

The formula is:

$$m = K\,S\,(T - t),$$

in which

T is in centigrade degrees the temperature of the fluid, either steam or hot water ;

t is in centigrade degrees the temperature of the room to be heated;

K is a coefficient, which Ser made equivalent to 11.44 for a radiator quite filled with steam, but which we reduce 9 to 10 per cent. to take account of the air which remains in the radiator, and of the necessity of having the radiator not hot even to its extremity, in order to avoid steam escaping through the return piping open to the atmosphere.

For low-pressure steam heating:

$K = 10$ (number of calories per square meter radiator and per one deg. C. difference between the inside steam temperature, and outside air temperature.

$T = 100$ (temperature of steam at atmospheric pressure).

$t = 18$ (temperature of the room to be heated).

$S =$ Square meters of radiator surface.

$$m = K\,S\,(T - t) = 10\,S\,(100 - 18) = 820\,S.$$

Many engineers have special tables giving the value of K, which decreases with the heights of radiators and their number of sections. When the radiators used are gills pipes, the gills or fins being of solid metal and simply go to extend the area of radiating surface, we allow for the value of K 60 to 70 per cent. of the above numbers. When radiators or gills pipes are placed inside grill casings we allow for radiation power K 80 per cent. of that of naked apparatus.

With hot water, we take for the value of T the mean temperature of the water into the radiator, the figure which was made the basis of calculations for the piping. Here, the practice is different, according to the engineers. Some allow 30 deg. C. difference between inlet and outlet, in order to have large radiators and small piping. Some others allow only 20 deg., so that they have smaller radiators and larger piping.

For the first hypothesis the average temperature is, for example:

$$T = (90 + 60) \div 2 = 75 \text{ deg.},$$

and, for the second:

$$T = (90 + 70) \div 2 = 80 \text{ deg.}$$

The radiation per square meter of radiator: $m = K\,S\,(T - t)$ is then 400 to 500 calories, when value of K is varying from 7 to 9, according to the types of radiators, their heights and the number of sections. When using gills pipes the value of K is taken as 60 to 70 per cent. (about 4, 5 to 6). When radiators or gills pipes are placed inside grating casing, the value of K allowed is 80 per cent.

Calculation with Indirect Heating.—When indirect heating is required, the calculations are quite different. We previously considered only the number M_1 calories flowing through the walls. From it we deduce the number Q of cubic meters of hot air which,

arriving to the registers with a given temperature T_a, and escaping by ventilation at the temperature of the room t, give up inside this room M_1 calories:

$$Q = \frac{M_1}{0.307\ (T_a - t)}$$

Generally, $T_a = 55$ deg. C. with low-pressure steam, and 45 deg. with hot water, the figures varying, of course, according to the types of radiating surfaces and cooling in the flues.

We afterward calculate the number M_2 of calories which it will be necessary to supply to the volume Q in order to increase its temperature from θ (outside temperature) to T_a (temperature to the registers), and adding some degrees t_a (for example, $t_a =$ deg.) lost in flues:

$$M_2 = 0.307\ Q\ (T_a + t_a) - \theta$$

Then it is the number M_2 calories which is to be supplied by the radiating surface, which is calculated according to this formula:

$$M_2 = K\,S\ \left(T - \frac{(T_a + t_a) + \theta}{2}\right)$$

in which:

T is the temperature of the steam, or the average temperature of hot water.

K is a coefficient varying with the velocity of the air.

For an ordinary circulation by gravity, we give to K the approximate following values:

Low pressure steam $\begin{cases} \text{radiators } K = 11.44 \\ \text{gill pipes } K = 6.5 \text{ to } 8 \end{cases}$

Hot water .... $\begin{cases} \text{radiators } K = 8 \\ \text{gill pipes } K = 4.5 \text{ to } 6 \end{cases}$

With a fan circulation, coefficient K varies according to the velocity of the air, namely:

For steam:

$K = 11.44$ for $v = 1$ meter per second,
to $K = 40$ for $v = 10$ meters per second.

Practically, we rarely have v greater than 5 meters per second, and for that velocity, $K = 32$.

For steam gills pipes, values of K are 60 per cent. of the values noted.

For hot water radiation:

$$K = 8 \text{ for } v = 1 \text{ meter per second.}$$
$$\text{to } K = 25 \text{ for } v = 5 \text{ meters per second.}$$

In the same way, for hot water gill pipes, K is 60 per cent. of above values.

The hot air flues are calculated from the following formulas:

$$Q = \omega V$$

$$V = 0.5 \sqrt{2\,gH \times \frac{0.003665}{1 + 0.003665} \times (T_n - t)}$$

in which:

Q is the volume in cubic meters at temperature t of the room to be heated;

ω is the area of flue in square meters;

V is the velocity of the air in meters per second;

g is the acceleration of gravity $= 9.8088$;

H is the height in meters from the middle height of the radiating surface to the register; 0.003665 is the coefficient of dilatation of the air (increasing in volume of the air for 1 deg. C.);

T_n is the temperature, deg. C. of hot air at the register;

t is the temperature of the room.

With fan systems, the most generally admitted velocities vary from 5 meters per second into main flues to 2 meters into branches, and 1 meter into the box at the registers. In all cases the outlet velocity from the registers is never allowed more than 0.25 to 0.50 meter per second.

Calculation of Boilers.—Competent engineers never accept for the calculation of steam boilers a vaporization greater than 15 kg. per square meter, which is about 8000 calories. For hot water, they admit from 8000 to 10,000 calories maximum per square meter. Unhappily second-rate jobbers very often depend on quite exaggerated catalogue ratings of boilermakers, who do not hesitate to guarantee 10,000, 12,000, and even 15,000 calories per square meter. With such performances, which are, indeed, often possible on account of the heights of our chimneys, there is considerable non-vaporized water forced through steam piping, with water hammer and an intense and tumultuous vaporization, which often causes the boilers to be burnt or broken, and always accompanied by a waste of coal. All of this causes lawsuits, during which the experts are obliged to install more powerful boilers.

We generally use large grate areas, calculated for 30 to 40 kg. of coal for each square meter grate. The commonly used coal is the anthracite, which is supplied from north of France, Belgium, and chiefly England (Wales). We began some years ago to use gas coke, but it is found too expensive. The cost of anthracite coal is, according to quality, from 50 to 60 fr. per ton of 1000 kg.; its calorific power is about 8000 to 8300 calories per kilogram, with 3 to 6 per cent. ashes. The cost of gas coke in the towns is 40 to 45 fr. per ton of 1000 kg., with 10 to 15 per cent. ashes, and its calorific power is 6000 to 7000 calories per kilogram.

PIPING

We generally use iron pipe from ⅛ to 4 inches connected with threaded fittings, and steel pipe with brazed flanges for larger diameters.

Our iron pipe is not always of good quality but is made in three grades, namely: butt-welded, mainly used for gas pipes but used for steam and water on some of the cheaper installations. Lap-welded, mostly used for steam work, and notch-welded pipe of higher grade and used for special work.

FITTINGS

The fittings used are mostly Swiss and German, made of malleable iron, smooth and of excellent quality; also they are made in more sizes than are given in the American catalogs, namely, ⅝, 1¾, 2¼, 2¾, 3½ inches and they can be procured so much more quickly than those made in America.

TOOLS

American tools made for Walworth thread are largely used here, but the German tools are also used on account of the convenience in procuring them. Very few pipe tools are made in France.

INSULATING COVERINGS

Excepting in the cheap installations all boilers and pipes are covered with some sort of insulating material. That most in use is asbestos plaster put on the same as mortar. There are moulded forms for both boiler and pipe covering, also there are several forms of corrugated air cell covering on the market. Cork is also used to considerable extent.

LOW PRESSURE STEAM HEATING

For about fifteen years low pressure steam heating was in great vogue in France, and on mostly all such systems (Fig. 1) we use the fractional or graduated valves. I presented a paper in 1901 describing the French system, (see Vol. VII of the Society Proceedings) though the steam pressure carried on steam systems as now used is much less, never going over one and a half pounds.

HOT WATER HEATING

Heating by hot water is growing in favor in France on account of its ability to maintain a more even temperature than is the case with steam as it is operated in this country.

The people will not attend to shutting on and off the valves which is necessary in the graduated valve steam system while the hot water apparatus can be regulated by one controller at the heater.

CALCULATIONS OF PIPING

Our formulas for calculating the size of piping take into consideration the pressure, length of pipe, and the friction on all the fittings and valves. Hence only the firms having competent engineers are able to solve correctly the problem of the circulation of steam through the pipes, and that of their frictional resistances.

Other firms use tables, curves or charts giving more or less correct results, but requiring regulation at the valves on the apparatus.

Some engineers calculate the frictional resistance by German formulas of Rietschel.

Most engineers of French education use the Ser formula, or the more precise formula of Maurice Levy.

The Ser formula is:

$$p_1 - p_2 = K \times \frac{Q^2 L}{D^5}$$

or

$$D = K \sqrt[5]{\frac{Q^2}{\frac{p_1 - p_2}{L}}}$$

in which:

p_1 is the steam pressure (in millimeters of water) at the inlet of the pipe;
p_2 is the pressure at the outlet of pipe;
K a given coefficient,
Q the weight in kilogrammes of steam per hour,
D the diameter of pipe in meters,
L the length of pipe in meters.

By that we know p_1, pressure to the inlet of pipe, for example 50 grammes per square centimeter, (0.71 lb. per sq. inch), and p_2, pressure we intend to keep to the radiator valve, for example 4 grammes (.0569 lb. per sq. inch), and equally we know L, length of the pipe, the calculation only depends on the coefficient K.

Then the formula is easily put according to a logarithmic form:

$$\log. D = \frac{\log. Q}{2.5} - \frac{\log. \dfrac{p_1 - p_2}{L}}{5} + \log. K$$

and accordingly a calculation-staff (Fig. 2), with 3 movable reglets, is very easy to handle.

Unfortunately, the coefficient K, which represents together the frictional resistances through the pipes, tees, elbows, bends, valves, radiators, etc., is not exactly fixed, on account of the steam condensation in the piping.

Mr. Ser proposed the value 0.0322, accepted by numerous heating engineers, and which, in spite of a probable inaccuracy, as it does not consider the velocities, it gives excellent results in numerous cases, especially considering it is always possible to correct a little error by more or less reducing the way of the fractional valve.

We think the formula may be sufficient to provide for most cases, and very convenient to use with the special calculation-staff, (Fig. 2).

When it is necessary for correcting errors, to calculate more accurately, it is easy to make a verification with the more precise German formula of Rietschel.

$$D = 0.001 \sqrt[5]{\frac{L\,C\,(C + C^1)}{p_2 - p_1}}$$

C being the useful number of calories passing through the pipes,
C^1 the number of calories from the steam condensation in the pipe, this pipe either being installed, or being previously calculated with Ser formula.
L, p_1, p_2, being the same as in Ser formula.

Such a formula can be as quickly solved by engineers having a sufficient use of logarithms, as C, C^1, L, p_1, p_2, are known or fixed, and consequently, $\frac{L}{p_1 - p_2} = A$ is known.

$$\log. D = \log. 0.001 + \frac{\log. A}{5} + \frac{\log. C}{5} + \frac{\log. (C + C^1)}{5}$$

but it does not allow the use of a special calculation-staff, and consequently necessitates for the large installations very long and fastidious calculations (as is generally the case with all the German formulas).

RETURN PIPING

Generally, we do not calculate this piping, to which we give sizes large enough to allow the flow of water together with the escaping of the air from radiators and pipes. The sizes tabulated are used by many heating engineers.

CONDENSATION Weight of water per hour		Sizes of return pipes, inches	
Kilograms	Equivalent pounds	Vertically	Horizontally
Up to 10	Up to 22	3/8	1/2
From 10 to 20	From 22 to 44	1/2	1/2
" 20 " 30	" 44 " 66	1/2	3/4
" 30 " 50	" 66 " 110	3/4	1
" 50 " 80	" 110 " 176	1	1 1/4
" 80 " 100	" 176 " 220	1	1 1/2
" 100 " 150	" 220 " 330	1 1/4	2
" 150 " 200	" 330 " 440	1 1/2	2 1/4
" 200 " 250	" 440 " 550	2	2 1/2
" 250 " 300	" 550 " 660	2 1/4	2 3/4
" 300 " 400	" 660 " 880	2 1/4	3

Yet, it is possible, without disadvantage to use smaller pipes, by allowing the air to escape at higher positions through small air pipes.

We think it is important to emphasize that this system when well equipped makes use of air valves quite needless, air valves being found undesirable by French people, because of the disagreeable smell of lye and stagnant water that escapes with the air.

HEATING BY HOT WATER

With this system we use boilers similar to those of steam heating, either wrought iron or cast iron.

The determination of sizes of pipes is a most important matter, and, in five years we have made considerable progress towards a standard, the practice, however, is not yet uniform.

We previously explained how we calculate the radiating surface, by fixing the temperature T_1 of the entering water, and temperature T_2 of that leaving. More often, we allow $T_1 = 85$ deg. C. (185 deg. Fahr.), so that for the maximum difference with outside temperature we have at the boiler 90 deg. C. (about 194 deg. Fahr.), by taking account of heat lost by radiation and pipes, the return water is 65 deg. C. (149 deg. Fahr.), so that:

$$T_1 - T_2 = 20 \text{ deg. C. (about 36 deg. Fahr.)}.$$

We deduce from the heat lost the volume of water in liters which is necessary to pass through the radiator to give out M calories:

$$Q \text{ (in liters)} = \frac{M}{20}$$

The head or motive force which produces the circulation is known, as we know (Fig. 3) the heights H_1, H_2, H_3, from the centers of boiler and radiators, and specific gravities (weights) V_1 and V_2 corresponding to the temperature of water T_1 and T_2.

The head is:

$$E = H_{1,\,2 \text{ or } 3} \times \left(1 - \frac{V_1}{V_2}\right)$$

or, as V_1 is very near to 1, weight of water at 4 deg. C. (39 deg. Fahr.):

$$E = H_{1,\,2 \text{ or } 3} \times (V_2 - V_1)$$

Then it is only a simple problem in hydraulics to determine the size pipe which allows a volume Q (in liters of water) to pass through under a head E.

FORMULA OF DARCY AND PHILIPPS

Numerous engineers use the formula of Darcy, corrected by Philipps, which is:

$$D = 0.334 \sqrt[5]{\frac{Q^2}{J}}$$

where:

D is the inside diameter of pipe (in meters).

Q the weight of water (in kilogrammes).

J the loss of head by friction of pipe for one meter, which is, for the maximum, $\frac{E}{L}$, which is to say the head as previously determined divided by the length (in meters) of the pipe.

This formula is very easy to use, as it may be transformed into logarithms:

$$\log. D = \log. 0.334 + \frac{2}{5} \log. Q - \frac{1}{5} \log. J$$

which can be made in the form of a special calculation-staff allowing one to immediately get the diameter.

It is not absolutely correct, but is on the safe side.

The coefficient 0.334, which corresponds to incrusted pipes was established by Darcy as an average between the two inch pipe (coefficient 0.000765) and the 20 inch pipe (coefficient 0.000532).

For smaller pipes used in heating systems, this coefficient takes the following values:

For	½	inch	pipes	0.3888
"	¾	"	"	0.3756
"	1	"	"	0.3653
"	1¼	"	"	0.3574
"	1½	"	"	0.3517
"	2	"	"	0.3460
"	2½	"	"	0.3420
"	3	"	"	0.3368

It is, then, very easy, after the first calculation with the coefficient 0.334 of the formula, to use a correcting factor by taking account of the above exact values.

It is what almost all the engineers used to do with the formula of Darcy, and who take care of local resistances of elbows, tees, valves, etc., by adding to the true length of the pipe an arbitrary length to represent the friction losses.

FORMULA OF FLAMANT

Numerous engineers use the formula of Flamant, although it was fixed after experiments on cold water circulations.

It is presented on the form:

$$J = 0.0014\, L \sqrt[4]{\frac{Q^7}{D^{19}}}$$

from which we can write:

$$D^{19} = \frac{(0.0014)^4\, L^4\, Q^7}{J^4}$$

the expression quite calculable by logarithms:

$$19 \log. D = 4 \log. 0.0014 + 4 \log. L + 7 \log. Q - 4 \log. J$$

and consequently easily transformable into a calculation-staff with 3 moving reglets.

It is equally foreign to this formula not to take account of local resistance but to represent them by arbitrary lengths of pipes, they have been based only on cold water circulation.

This formula gives very satisfactory results, and numerous installations figured according to this method have proved its value.

GERMAN FORMULAS

A number of French engineers, as well as the German engineers employed by French firms, prefer the methods derived from the German formulas of Rietschel, or of Recknagel, or yet of Brabbée, for the first time published at the meeting of German heating engineers in Cologne in (July, 1913), after three years experiments at the laboratory of Charlottenburg under the direction of Professor Rietschel.

Mr. Nillus, in a series of papers presented by him at monthly meetings of the French Association of Heating and Ventilating Engineers (especially March 15, May 19, 1911, December 5, 1913), was the zealous champion of German methods, and disdainfully says that French methods are only approximate methods.

I will only say, for my own part, that I do not use formulas without knowing how they were determined, and that I do not take all for granted because it is imported from Germany. The

German laboratories give formulas without particulars regarding their basis. As long as my own practice will not prove to me that installations calculated according to German methods work more satisfactorily than according to our own, so long will I not be confident of their greater precision.

Professor Rietschel says Weisbach's coefficient is too great for large diameters (without saying what size pipe he considers is a large diameter).

The coefficient of Weisbach is:

$$K = 0.01439 + \frac{0.0094711}{\sqrt{v}}$$

It will be easy to understand how such a coefficient complicates the calculations when the expression ignores the diameter of the pipe in the formula. The velocity appears to be constant, while as a matter of fact it changes with every size pipe.

In similar manner, what Professor Rietschel calls "local resistances," that is to say, the losses of head by changing the direction of the flow, through elbows, tees, etc., or changing the form of the liquid (entering or leaving boilers, radiators, ways through valves, etc.), he proposes the formula:

$$\frac{v^2}{2g} Z$$

giving for Z the following values as results of his own experiments, but without particulars as to these experiments:

Square elbow:	$Z = 1$
Long radius elbow:	$Z = 0.5$
Double bend elbow:	$Z = 0.8$
Large sudden increasing or decreasing of volume:	$Z = 0.8$
Open valves:	$Z = 0.5$ to 1
Open cocks:	$Z = 0.1$ to 0.3

But Prof. Rietschel, in giving these coefficients takes care to inform us they are incorrect as to friction especially for large diameters.

Really, we think that German formulas are no more to be relied on than our own for cold water circulation. But what we do know is that their use leads to very long, complicated and fastidious calculations, subject to errors that consume time and energy to correct, yet they must be checked to avoid serious losses.

In my own experience during 25 years with the firm of Leroy and Co., I used the formulas of Philipps and Flamant, both giving very good results. They allow me to quickly calculate; and I was able, in a few minutes, to check the calculations of my draughtsmen, which would be almost impossible with German formulas.

It will be noticed that with calculation-staffs (Fig. 2) all the combinations are possible.

One of these I prefer consists in dividing the water circulation into three parts, each part considered as working with its own head, see (Fig. 4):

1.—Piping in the basement, which may be of large size, but properly protected with good pipe covering, works according to a head E_1 corresponding to the height h_1.

2.—The risers, which it is preferable to have as small as possible, work according to a head E_2 corresponding to the height h_2.

3.—Finally the radiators, considered as being connected in derivation on the risers, and which work according to a head E_3, corresponding to their own height, and varying for each of them.

Of course, $E_1 + E_2 = E$,
as $h_1 + h_2 = H$.

The advantage of this method will be immediately noticed, as it takes account of the temperatures in all the parts of the circulation, whereas the German method requires only to consider the temperatures of the water entering and leaving the boiler, which is certain to lead to errors.

HOT WATER HEATING WITH ACCELERATED VELOCITY OF THE CIRCULATION

In the large French towns, and chiefly in Paris, number of people live in flats, or buildings with numerous floors.

Each tenant with his family usually occupy one floor, or part of the same floor, which is to say that the rooms of his whole apartment are located on the same level.

The more recently erected buildings are partly provided with a system of central heating, by low pressure steam or by hot water, and the proprietor charges each tenant for his incumbent part of heating according to a yearly rent.

But buildings of ten or fifteen years old are not all heated, and often it is necessary for the tenant to provide his apartment

with heating, by means of a system which is portable and which he can carry off to a new apartment.

Portable systems for this purpose are shown in (Fig. 5). In such an apparatus the circulation is accelerated by high temperature.

In most of the systems, shown by the principle on which the velocity of the water flow is based is that of the "emulsion," that is to say, we bring into the riser AB between the boiler and the expansion tank, some percentage of steam which lessens the specific weight of the water column.

By neglecting the syphon performed by risers EF and GH, which have to be considered only for the resistances of friction of their pipes and elbows, is given by the formula:

$$E = h_1 \times \left(1 - \frac{V_0}{V_1}\right) + h_2 \left(1 - \frac{V_0}{V_1}\right)$$

by taking account, for determining V_0 of:

$$H V_0 = h'_0 V'_0 + h''_0 V''_0$$

We cannot describe here all the systems of acceleration patented in France; but they are very numerous.

They all circulate at high temperature but the heat can be regulated at the radiators which are always supplied with fractional valves.

They require a sensitive regulator at the boiler, but regardless of this they frequently boil over and accidents do happen by which the boiler is broken.

A number of the patents issued are to prevent accidents and to save the heat lost by boiling over. Of these patents we may mention (Reck, Bruckner, Hamelle, Chebout, Koerting, Nissi Brothers, etc.).

Recently, the Compagnie Nationale des Radiateurs, (branch of American Radiator Co.) introduced the system in which the steam is confined in a closed cell of the expansion tank, its pressure controlled by a Sylphon damper regulator.

This closed cell is connected, through a syphon 2.50 meters (about 8 feet 3 inches) with another cell in communication with the atmosphere through an overflow pipe, and which is the expansion part of the tank.

With this system, the Compagnie Nationale des Radiateurs advises sizes of pipes given in the accompanying table:

Length of go and return pipes From boiler to radiator		Maxima number of Calories able to be carried to the distances of first column Through below pipes:						
Meters	Corresponding feet about	⅜"	½"	¾"	1"	1¼"	1½"	2"
5	16.50	2000	3500	7000	14000	25400	41000	72000
10	32.10	1400	2500	5000	10000	18000	29000	51000
15	49.30	1100	2000	4300	8000	14800	22800	41700
20	65.70	900	1700	3600	7000	12700	20500	36000
25	82.10	850	1550	3200	6300	11200	18400	32200
30	98.50	800	1400	3000	5700	10200	16800	29300
35	114.10	750	1300	2800	5300	9600	15600	27200
40	131.30	700	1200	2500	5000	9000	14500	25500
45	147.90	650	1150	2400	4700	8500	13700	24000
50	164.20	600	1100	2300	4400	8000	13000	22800
55	180.60	550	1050	2150	4200	7700	12500	21700
60	196.10	500	1000	2000	4000	7400	12000	20700
65	213.30	450	950	1950	3850	7100	11500	19950
70	229.80	400	900	1900	3700	6800	11000	19200
75	245.40	375	875	1850	3550	6500	10665	18600
80	262.60	350	850	1800	3400	6325	10330	18000
85	279	325	825	1750	3300	6160	10000	17500
90	295.60	315	800	1700	3200	6000	9725	17000
95	302	307	775	1650	3150	5850	9460	16600
100		300	750	1600	3100	5700	9200	16200

HOT BLAST HEATING BY FANS

This method of heating has not received as much attention in France as it has in the United States owing to the difficulty of introducing it into old buildings.

It is used to some extent in public buildings, banks, factories, etc. We prefer to pass only cold air through the face which is different from the practice in the United States. We use air filtration methods see (Fig. 6) made with panels of wadding sheets.

We also wash and humidify the air either with air washers or pulverizators, these are usually preceded by a radiator to prevent freezing.

The blowers used are those of Farcot Lambert Bros., Pinette Sturtevant, Leroy & Co., Fouche, Blackman, etc.

The heaters used are mostly cast iron extended surfaces called (gill pipes) and wrought iron pipes with added or soldered gills or fins, to extend the surfaces.

Some installations for smoking rooms, restaurants, kitchens, and so forth, use ozone to eliminate the odors, etc.

Some installations have been made for cooling the air in the summer weather. In these cold water pipes are used in some and brine pipes in others to cool the air as it circulates over such surfaces. Ice is never used for this purpose, except in powder mills, magazines, etc.

DISTRICT HEATING

Heating from central stations has not been introduced in France, as yet, largely owing to the fact that the towns and cities are old and the streets being so much occupied with pipes, sewers, mains, etc., that it is difficult to get councils to grant rights to a company for this purpose.

Our colleague, Mr. Beaurrienne, presented in 1912 and 1913, two very remarkable and learned papers to the French Society of Civil Engineers. He is a strong advocate of central station heating for towns and cities.

The only examples we have of this kind are in groups of buildings such as large factories, asylums, hospitals, etc. In such plants the steam is distributed at a pressure of about 85 pounds and reduced by a valve located in each building of the group. See my paper, Vol. VII, 1901 for the type of reducing pressure valve used.

AUTOMATIC CONTROL OF TEMPERATURE

Automatic control of temperature is not much in favor in France, but some few installations such as the (Credit Lyonnais Societe Generale) and some large hotels and restaurants. French people spare expense wherever possible and watch the radiators closely that no heat is wasted.

What regulators there are used, are mostly those of Grouville and Arquembourg, Dorian, Fournier, Hegner.

CONCLUSION

As briefly as possible, I have tried to point out the position in France of heating and ventilation theory and practice.

I did not speak of the final inspection of heating installations, because, except for great state buildings or city administrations which have consulting engineers, the inspection for acceptance of plant is rarely performed. It is often admitted that an installation proves satisfactorily working when no objections are made the first winter after its erection, the guarantee delay being one year.

When objections develop, the architect orders the contractor to make a test, the conditions of which he is often unable to con-

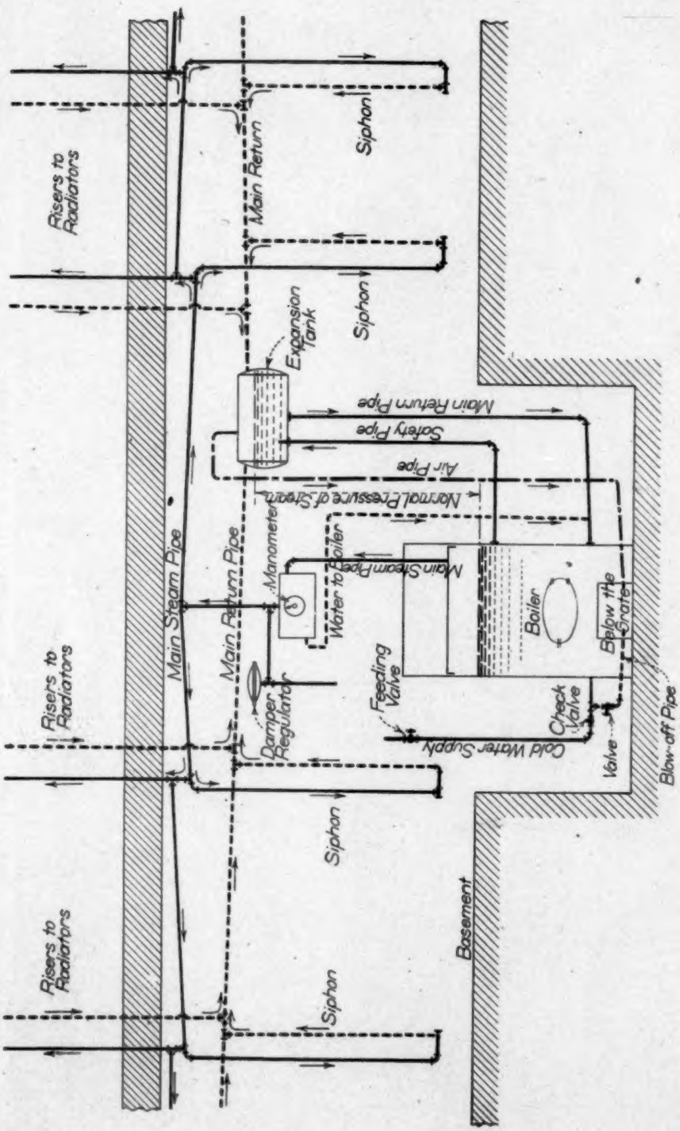

Risers to Radiators
Main Return
Siphon
Risers to Radiators
Siphon
Expansion Tank
Main Return Pipe
Safety Pipe
Air Pipe
Normal Pressure of Steam
Main Stream Pipe
Main Return Pipe
Manometer
Water to Boiler
Main Steam Pipe
Boiler
Below the Grate
Risers to Radiators
Damper Regulator
Feeding Valve
Check Valve
Cold Water Supply
Valve
Blow-off Pipe
Siphon
Basement
Risers to Radiators
Siphon

Fig. 1

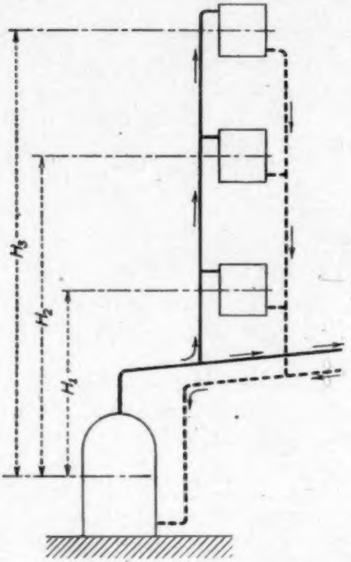


Fig. 3

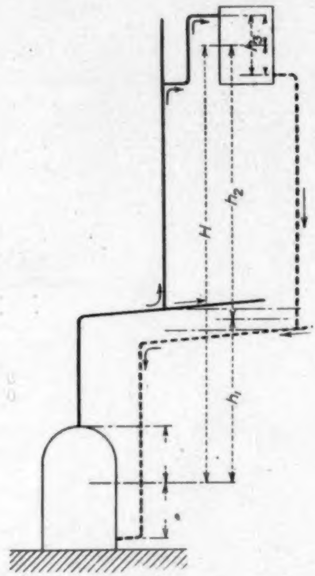


Fig. 4

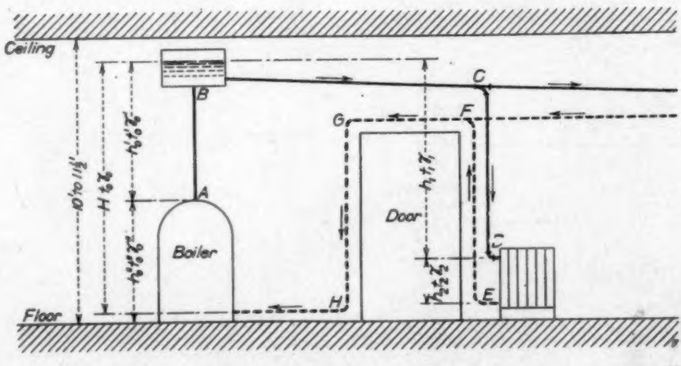


Fig. 5

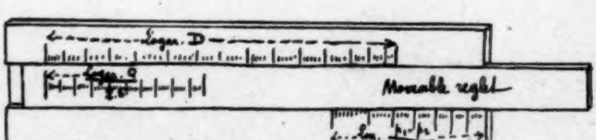


Fig. 2

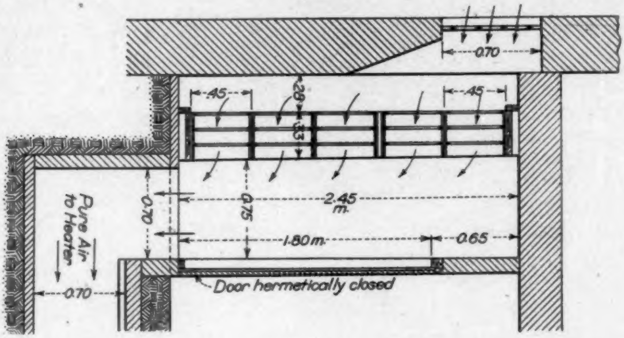


Fig. 6

trol. Generally are then applied the special rules of the Syndicate (Chambre Syndicale) of the Constructors of Heating and Ventilation Apparatus.

It is only when an action is brought against the constructor that legal experts intervene to verify, according to all the known methods, if all the conditions of the contract are entirely fulfilled by the contractor.

DISCUSSION

Mr. Barron: I want to say a few words briefly on this magnificent paper, and I think it is creditable to the Society that we have received it. What I want to get on our record, possibly is the fact that General Moran, a Frenchman, of 40 years ago, published a great deal of work with regard to ventilation. It was an exceedingly valuable work in the early days, and, I have no doubt, stimulated a great deal of the American practices in ventilation, and I do not think the author of the paper refers to the earlier workers in the heating and ventilating line at all, he gives present day practice, which of course, is exceedingly valuable, but it is not well I think, to forget the earlier practitioners, and General Moran was highly regarded by all the early workers, I am sure, in the heating and ventilating field.

Mr. Bolton: Mr. Chairman, it is not usual to go out of our way to compliment an author upon a production presented before the Society, because we would like to take all we can get, and have everybody feel that in giving they are benefiting

themselves, as well as others; but we might record the fact that we appreciate a foreign member going to so much trouble as he has done, in giving us so wide a view of practice in another country. It is so highly interesting a paper, that if it is not out of order, I would move that this particular gathering send a vote of thanks to our good fellow-member, for taking the pains to give us this interesting material.

The Chairman: You have heard the motion that the thanks of the Society, as represented by the members present, be sent to our fellow-member in France, for this interesting paper. Carried unanimously.

Mr. Donnelly: I am sorry this paper was not printed, because I am very much interested in some of those things, and as to whether the French method has been adopted over here—it has been very close to it.

Without mentioning the names of others, I really consider that this great change in the heating apparatus in the last five years has been toward the French method, and we are discarding the method of all heat, and no heat valves, and I am surprised at some of the larger concerns with whom heating was but a very small item, as to the care with which they are now studying the heating problem. I might mention a large packing house in New York City, that has very large plants for refrigeration. Their total heating is a very small percentage of their mechanical work. You might say that their heating requirements are not five per cent. of their other requirements, such as refrigeration, and other powers, and yet I find their master mechanic had spent three or four weeks in getting samples of valves, and having men call upon him to go into the study of heating for their minor requirements.

They made tests of valves, and went into things much more than formerly. I saw some of the apparatus in the old building, which was of the old fashioned type, with small pipes, and high pressure radiators, and it seems they were discarding them, and making a close study of a method of heating, without air valves, and of this French control, of the inlet valve, or Tudor control, as it was called in this country. It seems to me that it is very encouraging that people who had really taken almost anything as good enough in the heating line are now looking into the thing, and trying to get a superior article. They were making requirements that the pressure should not be over one-half pound.

CCCXXXIX

FLOW OF STEAM IN PIPES

BY W. F. VERNER

In making a careful study of the flow of steam in pipes the author learned that several equations have been evolved foi use in such calculations, but unfortunately have been seldom used due no doubt to the difficulty of solution. After studying such authorities on the subject as Goodenough, Ennis, Rietschel, Weisbach, Meier, Eberle, Paulding and Marks and Davis, he decided to take these fundamental equations and put them in such form that logarithmic charts may be made, as by so doing the solution of various problems is made much simpler. Accordingly the subject has been treated as applying to low pressures, BETWEEN ATMOSPHERIC AND 3 LB. PER SQUARE INCH GAUGE.

FUNDAMENTAL PRINCIPLES RELATIVE TO STEAM

If we apply heat to a vessel of water open to the atmosphere, an increase of temperature and a slight increase of volume may be observed. The increase of temperature represents a gain of internal energy; the slight increase of volume against the constant resisting pressure of the atmosphere represents the performance of external work, the amount of which may be readily computed. After this operation has continued for some time a temperature of 212 deg. F. is attained and steam begins to form. The water now gradually disappears; the steam occupies a much larger space than the water from which it is formed; a considerable amount of external work is done in thus increasing the volume against atmospheric pressure and the common temperature of the steam and water remains constant at 212 deg. F. during evaporation.

The same operation may be performed in a closed vessel, in which a pressure either greater or less than that of the atmosphere may be maintained. The water will now boil at some other temperature than 212 deg. F.; at a lower temperature than 212 deg. if the pressure is less than atmosphere and at a higher temperature if greater.

The latter is the case in an ordinary steam boiler. If the water be heated until it is all boiled into steam it will then be possible to increase the temperature of the steam or in other words superheat it, a result not possible so long as any liquid is present. For each pressure there is a fixed boiling point or temperature of ebullition.

Consider a cylinder containing 1 lb. of water subjected to a pressure of 200 lb. per square inch absolute as in Fig. 1. Consider also that the temperature of the water is 32 deg. F. and it has a volume of W/y where W equals the weight and y is the density. If heat is applied the temperature will be raised and if sufficient heat is added the temperature will rise to 381.9 deg. F. and the volume will be increased slightly. (See Marks and Davis steam tables.) The heat added or h equals 354.9 B. t. u. The internal energy increase equals 354.2 B. t. u. and the external work done will be equivalent to the difference or 0.7 B. t. u. If we apply still more heat we will find that the temperature does not increase but that the volume increases rapidly. The temperature will remain constant until the water has received a total amount of heat equal to 1198.1 B. t. u., which means that 1198.1 minus 354.9 B. t. u. has been used to evaporate the water. The internal energy has been increased by 759.5 B. t. u. and the external work due to the increase of volume to the final volume of 2.290 cu. ft. represents the equivalent of 84.4 B. t. u.

Comparing the heat values of 1 lb. of water at 32 deg. and 1 lb. of water at 381.9 deg. and 1 lb. of steam at 381.9 deg. and 200 lb. per square inch absolute pressure we have the following.

	Temperature	Volume Cu. Ft.	B. t. u. above 32 Deg.	B. t. u. Equivalent to External Work	B. t. u. for Vaporization	B. t. u. Equivalent to External Work of Vaporization	B. t. u Equivalent to Internal Energy	B. t. u. Equivalent to Internal Energy of Vaporization
1 lb. of Water at 32 deg	32	0.016						
1 lb. of Water at 381.9 deg ...	381.9	0.020	354.9	0 7			354.2	
1 lb. of Saturated Steam at 200 lb. per sq. in. abs. and 381.9 deg	381.9	2.290	1198.1	84.4	843.2	83.7	1113.7	759.5

From the foregoing it is evident that if 1 lb. of dry saturated steam at 200 lb. per square inch abs. was confined in a vessel it would be

necessary to abstract more than 843.2 B. t. u. before the temperature could be reduced below 381.9 deg. F. Thus dry saturated steam serves as a great heat carrier. If 1 lb. of dry saturated steam under the foregoing conditions occupying a volume of 2,290 cu. ft. should

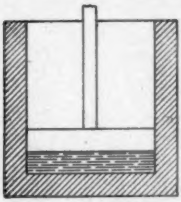


FIGURE 1

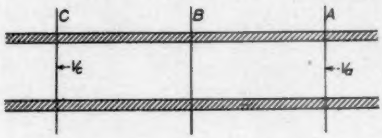


FIGURE 2

be conveyed from one place to another it would be equivalent to transmitting 1198.1 B. t. u. as compared with the value of 354.9 B. t. u. for 1 lb. of water at the same temperature and 40,656 B. t. u. for 114.5 lb. of water at 381.9 deg. occupying a volume of 2,290 cu. ft.

For the same volume water is capable of carrying more heat in the foregoing case by nearly 40 times but the weight is over 100 times that of the steam.

Assume for another comparison steam at atmosphere pressure and we have the following table.

	Temperature	Volume Cu. Ft.	B. t. u. above 32 deg.	B. t. u. Equivalent to External Work	B t. u. for Vaporization	B. t. u. Equivalent to External Work of Vaporization	B. t. u. Equivalent to Internal Energy	B t. u. Equivalent to Internal Energy of Vaporization
1 lb. of Water at 32 deg	32	.0160						
1 lb. of Water at 212 deg......	212	.0167	180	0.1			179.9	
1 lb. of Saturated Steam at 147 lb. per sq. in. abs. and 212 deg..........	212	26.79	1150.04	72.9	970.4	72.8	1077.5	897.6

For the same volume water is capable of carrying more heat in the foregoing case by nearly 240 times, but the weight is about 1600 times that of the steam.

Another interesting point relative to the heat carrying capacity of steam and water is in the case of pipes for heating requirements.

TRANSMITTING STEAM BY MEANS OF PIPES

The general theory of flow of elastic fluids is based upon two fundamental equations, which are derived by applying the principles of conservation of energy. Consider a section of pipe as shown in **Figure 2.**

Also assume the following symbols:—

A = a constant = $\dfrac{12(4 \times 144)^2 f}{2g(3600\pi)^2}$

a = internal area of pipe in sq. ft. = $\dfrac{\pi d^2}{4 \times 144}$

B = a factor = $\dfrac{\pi(t_m - t_a)k}{12L_m}$

D = outer diameter of pipe in inches

d = internal diameter of pipe in inches

f = friction coefficient

f^1 = amount of work due to friction per unit of weight

g = 32.16, a constant for gravity

H = amount of heat transferred

h = the quantity of heat in B.t.u. required per hour

h^1 = the quantity of heat in B.t.u. lost per hour

$h + h^1$ = total quantity of heat in B.t.u. entering the pipe per hour

h_s = head in feet of steam to overcome single resistances

h_f = head in feet of steam to overcome pipe resistance

I = heat effect of a change of physical state

k = transmission coefficient (B.t.u. per sq. ft. per hr. per deg. diff.)

L_1 = latent heat of vaporization at final pressure p_1

L_m = latent heat of vaporization for the average pressure

l = length of pipe in feet

M = mass = $w_1/29$

p = pressure in pounds per sq. ft. absolute

p_1 = abs. pressure of steam at the end of the pipe in lbs. per sq. in.

p_2 = abs. pres. of steam at the beginning of the pipe in lbs. per sq. in.

p'_2 = abs. pres. of steam at the beginning without considering the single resistances such as ells, tees, valves, etc., in lbs. per sq. in.

p''_2 = pressure of the steam at the beginning necessary to overcome the single resistances ΣS in lbs. per sq. in.

q = amount of heat per unit of weight

S = single resistance factor

$S^1 = T + I$

s = heat external surface of pipe per ft. of length in sq. ft. = $\dfrac{\pi D}{12}$

T = effect of a change in temperature

t_a = temperature of the air surrounding the pipe

t_m = temperature of the steam corresponding to average pres.

V = heat effect due to velocity

v = velocity in feet per second

w = quantity of steam in lbs. per hour required
w^1 = quantity of steam in lbs. per hour lost
$w + w^1$ = quantity of steam in lbs. per hour entering the pipe
w_1 = weight
W = heat effect of a performance of external work
y = density (lbs. per cu. ft.)
ΣS = summation of single resistance factors

If no heat is added or rejected with respect to the volume of steam moving from A to C the sum of $T + I + W + V$ must remain constant and

$$H = T_a + I_a + W_a + V_a = T_c + I_c + W_c + V_c$$
$$= S^1_a + W_a + V_a = S^1_c + W_c + V_c \tag{1}$$

W = pressure times a change in volume.

$V = \frac{1}{2} M v^2 = w_1 v^2/2g$

Assume w_1 = unity then

$$H = S^1_a + p_a/y_a + v^2_a/2g = S^1_c + p_c/y_c + v^2_c/2g$$
$$\text{or } (S^1_a + v^2_a/2g) - (S^1_c + v^2_c/2g) = p_c/y_c - p_a/y_a \tag{2}$$

which is the general equation for frictionless flow and no transfer of heat to or from an external source.

Let an amount of heat, q, leave the steam per unit of weight and the work of friction per unit of weight $= f^1$
then

$$(S^1_a + v^2_a/2g) - (S^1_c + v^2_c/2g) = q + f^1 - f^1$$
$$+ p_c/y_c - p_a/y_a$$

Note that the value of f^1 drops out and as the work done in overcoming the friction goes back into the fluid we have

$$(S^1_a + v^2_a/2g) - (S^1_c + v^2_c/2g) = q + p_c/y_c - p_a/y_a$$
$$\text{or } (v^2_c - v^2_a)/2g = -q + (S^1_a + p_a/y_a) - (S^1_c + p_c/y_c) \tag{3}$$

Equation 3 is the first fundamental equation.

The effect of friction is to alter the distribution between the energy S^1 and the energy $v^2/2g$ at section C leaving the sum total unchanged. Differentiating Equation 3 gives

$$v\,dv/2g + dS^1 + d\,(p/y) = -\,dq \tag{4}$$

Equation 4 considers only the initial and final conditions at *A* and *C* respectively and gives no information as to anything that occurs between these two points. Independently of the motion of the steam it may receive an increase of volume and therefore external work is done against the surrounding steam and S^1 may increase then

$$-\,dq + df^1 = d\,S^1 + pd\,(\tfrac{}{y}) \tag{5}$$

Combining Equations 4 and 5

$$v\,dv/g + (\tfrac{1}{y})\,dp + df^1 = 0 \tag{6}$$

Whence by integration

$$(v^2_a - v^2_c)/2g = -\int_{p_a}^{p_c} dp/y - f^1 \qquad (7)$$

The fundamental Equations 3 and 7 are perfectly general and hold equally well for gases, vapors and liquids.

From Equation 7

$$f^1 = \int_{p_c}^{p_a} dp/y - (v^2_a - v^2_c)/2g \qquad (8)$$

If $f^1 = 0$

$$\int_{p_c}^{p_a} dp/y = (v^2_a - v^2_c)/2g \qquad (9)$$

In Equation 9 the expression $\int_{p_c}^{p_a} dp/y$ represents an area which may be obtained if the rate of change of the pressure and density is known.

Consider the relation of pressure and density at various positions

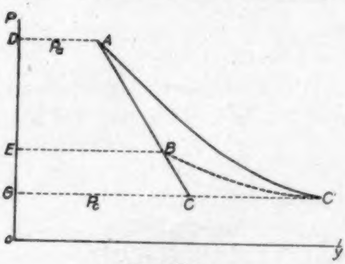


FIGURE 3.

between A and C as represented in Figure 3 by the curve AC for frictionless motion and by AC[1] for the case with friction.

$\int_{p_c}^{p_a} dp/y$ = area $ACGD$ = the change of kinetic energy $(v^2_a - v^2_c)/2g$ for frictionless motion.

Draw the constant heat line BC[1], then the change of kinetic energy represented by the heat change between A and C[1] equals that between A and B or the area ABED.

The difference in area between AC[1]GD and ABED represents the work of friction.

The foregoing theory is quite thoroughly taken up by Professor Goodenough in his Thermodynamics.

Referring to Fig. 2.

$$v = \frac{w}{3600\, ya} = \sqrt{2gh_a} = \sqrt{2g\frac{144\, p_1}{y}} \qquad (10)$$

The quantity of steam in pounds per hour required at any point must equal the quantity of heat required divided by the heat contents of 1 lb. of steam. In steam heating work it is advisable to assume that the heat content available is the heat of vaporization per pound of steam.

Then

$$w = h/L_1 \tag{11}$$

Also

$$w^1 = h^1/L_m \tag{12}$$

$$h^1 = sl\ (t_m - t_a)\ k_k \tag{13}$$

$$w^1 = sl\ (t_m - t_a) \frac{k}{L_m} \tag{14}$$

The necessary velocity in feet per second to supply a quantity of steam $w + w^1$ as it starts into the length l

$$v = \frac{w + sl\ (t_m - t_a)\ k}{3600\ y\ a\ L_m} \tag{15}$$

From reason and numerous observations we may assume that the resistance of friction increases directly as the length l and inversely as the diameter d and therefore proportional to the ratio l/d. If we measure this resistance by the height of a column of the fluid which must be deducted from the entire head in order to obtain the height requisite for the generation of the velocity we may put for this height which will be termed the height due to the resistance, $h_f = \dfrac{f\,l\,v^2}{\dfrac{d\ 2g}{12}}$ where f represents a number obtained from experiment.

h_f is equal to the pressure divided by the density then $h_f = p/y$.

Considering the resistance to the flow due to the surface of the pipe take an elementary length dl then the change of pressure due to the resistance encountered may be obtained from

$$\frac{dp}{y} = \frac{f\,dl\,v^2}{\dfrac{d\ 2g}{12}} \tag{16}$$

From the latest tests we may accept the value of 0.0300 for f (see appendix).

Substituting in Equation 16 the value of v of Equation 15 gives

$$= \frac{dp}{y} = \left[\frac{w + sl\,(t_m - t_a)\,k}{3600\,y\,a\,L_m} \right]^2 \frac{\frac{f\,dl}{d\,2g}}{12} \qquad (17)$$

The above equation may be reduced to the form

$$y\,dp = \frac{A}{d^5}(w + DBl)^2\,dl \qquad (18)$$

$$\text{where } A = \frac{12\,(4 \times 144)^2 f}{2g\,(3600\pi)^2} \qquad (19)$$

$$\text{and } \quad B = \frac{\pi\,(t_m - t_a)\,k}{12\,L_m} \qquad (20)$$

TRANSMITTING LOW PRESSURE STEAM BY MEANS OF PIPES

Assuming y constant we obtain upon integrating equation 18

$$p^1_2 - p_1 = \frac{Al\,[3w^2 + 3w\,DBl + (DBL)^2]}{d^5\,y \times 432} \qquad (21)$$

From equation 14 and 20

$$w^1 = DBl \qquad (22)$$

Then

$$p^1_2 - p_1 = \frac{A\,l}{d^5 y} \times \frac{3w^2 + w^1\,(3\,w + w^1)}{432} \qquad (23)$$

From equation 19

$$A = \frac{12\,(4 \times 144)^2 f}{2g\,(3600\pi)^2} = \frac{12\,(4 \times 144)^2\,0.0300}{2 \times 32.16\,(3600\pi)^2} = 0.0000142 \qquad (24)$$

Substituting in equation 23

$$p^1_2 - p_1 = \frac{0.00329\,l}{(10d)^5} \times \left[\frac{3w^2 + w^1\,(3w + w^1)}{y} \right] \qquad (25)$$

Since w^1 is small compared with $3w$ it can be neglected and

$$p^1_2 - p_1 = \frac{0.00987\,l}{(10d)^5\,y}(w + w^1)\,w \qquad (26)$$

Substituting values of equations 11 and 12

$$p^1_2 - p_1 = \frac{0.00987\, l}{(10d)^5\, y} (h/L_1 + h/L_m)\, h/L_1 \qquad (27)$$

The head h_s due to single resistances is

$$h_s = v^2/2g \times \Sigma S \qquad (29)$$

From equations 10, 14 and 15

$$v_s = \frac{w + w^1}{3600\, ya} \qquad (30)$$

Then

$$h_s = p^{11}_2/y = \frac{(w + w^1)^2\, \Sigma S}{(3600\, ya)^2\, 2g} = \frac{(w + w^1)^2\, \Sigma S}{144\, (12.55d)^4\, y} \qquad (31)$$

$$p^{11}_2 = \frac{(w + w^1)^2\, \Sigma S}{144\, (12.55d)^4 y} = \frac{(h/L_1 + h^1/L_m)^2\, \Sigma S}{144\, (12.55d)^4 y} \qquad (32)$$

Equations 27 and 26 enable the determination of the pressure drop in straight unobstructed pipes. If single resistances occur in the pipe line it is necessary to add the pressure drop due to those resistances to the pressure drop due to the straight pipe resistance. Adding the value of p^{11}_2 gives

$$p_2 - p_1 = \frac{0.00987\, l}{(10d)^5 y} (w + w^1)\, w + \frac{(w + w^1)^2\, S}{144\, (12.55d)^4 y} \qquad (33)$$

or

$$p_2 - p_1 = \frac{0.00987\, l}{(10d)^5\, y} (h/L_1 + h/L_m)\, h/L_1 + \frac{(h/L_1 + h/L_m)^2\, S}{144\, (12.55d)^4\, y} \qquad (34)$$

For ordinary work p^{11}_2 is small and if the diameters are to be calculated having the difference between the beginning and end pressures given or in other words the increase of pressure there follows if one neglects the local or single resistances

$$d = 0.0397 \sqrt[5]{\frac{l\, (h/L_1 + h/L_m)\, h/L_1}{(p^1_2 - p_1)\, y}} = 0.0397 \sqrt[5]{\frac{l\, (w + w^1)\, w}{(p^1_2 - p_1)\, y}} \qquad (35)$$

If the local resistances are to be considered, p^{11}_2 is to be calculated from equation 32, then subtracted from p^1_2 and this new value used instead of p^1_2.

In practice the steam pressure of a heating system is usually given or is to be chosen. In the radiator it is to be used up. Therefore at

the lower ends it approximates atmospheric pressure. Quite often the mistake is made of putting in a pipe connection to a radiator larger than necessary and then throttling the steam. This is quite likely to cause annoying noises. By choosing the right pressure drop in the pipe line and the steam pressure in front of the radiator, this noise may be entirely eliminated.

In regard to the pressure drop, it depends mainly upon the gauge pressure at the boiler and upon the length of the pipe line. One should not choose the pressure unnecessarily high if branch pipes end near the boiler.

The following are good values:—

1.0 lb. per square inch when steam is to be transmitted 450 ft.
1.5 lb. per square inch when steam is to be transmitted 650 ft.
2.0 lb. per square inch when steam is to be transmitted 800 ft.
2.5 lb. per square inch when steam is to be transmitted 1200 ft.
3.0 lb. per square inch when steam is to be transmitted 1600 ft.

In regard to the steam pressure immediately in front of the radiator it must be so chosen in a low pressure heating system that the steam is all used up in the radiator. This is very essential if one wants to obtain good regulation. To answer this it is necessary to use equation 33.

As the working pressure for low pressure heating covers but a small range it simplifies the equations by substituting an average value for L and y.

Using 3 lb. per square inch gauge as the boiler pressure the corresponding values of L and l/y are 964.3 and 22.50 and equation 35 becomes

$$d = 0.00474 \sqrt[5]{\frac{l\,(h + h^1)\,h}{(p^1_2 - p_1)}} = 0.0740 \sqrt[5]{\frac{l\,(w + w^1)\,w}{(p^1_2 - p_1)}} \qquad (36)$$

Using atmospheric pressure the corresponding values of L and l/y are 970.4 and 26.79 and equation 35 becomes

$$d = 0.00489 \sqrt[5]{\frac{l\,(h + h^1)\,h}{(p^1_2 - p_1)}} = 0.0766 \sqrt[5]{\frac{l\,(w + w^1)\,w}{(p^1_2 - p_1)}} \qquad (37)$$

If we use the equation

$$d = 0.0048 \sqrt[5]{\frac{l\,(h + h^1)\,h}{(p^1_2 - p_1)}} = 0.075 \sqrt[5]{\frac{l\,(w + w^1)\,w}{(p^1_2 - p_1)}} \qquad (38)$$

the error will be small when the working pressures are from 3 lb. per square inch gauge to atmospheric pressure.

Then

Equation 27 becomes $p^1_2 - p_1 = \dfrac{0.02554\, l\, (h + h^1)\, h}{(100d)^5}$ (39)

Equation 32 becomes $p^{11}_2 = \dfrac{0.00002585\, (h + h^1)^2\, \Sigma S}{144\, (12.55d)^4}$ (40)

Equation 33 becomes $p_2 - p_1 = \dfrac{0.02554\, l\, (h + h^1)\, h}{(100d)^5} = \dfrac{0.00002585\, (h + h^1)^2\, \Sigma S}{144\, (12.55d)^4}$ (41)

TABLES

Table A gives values of the dimensions for standard wrought iron and steel pipe as adopted January 1, 1913.

Table 1 gives values of d for different values of $h\ (h + h^1)$ and $\dfrac{l}{p^1_2 - p_1}$ for estimating purposes.

Table 2 gives values for the B. t. u. carried by standard pipes per hour neglecting heat loss from pipes for different pressure drops in 10 ft. of pipe.

Tables 3 and 4 give various values relative to standard pipes which are of service in solving the foregoing equations.

SINGLE RESISTANCES

The question of single resistances relative to steam heating practice seems to have had little attention in the testing laboratories and it is to be hoped that some authoritative data will be forthcoming in the near future.

Considerable work has been done by several companies relative to the flow of air, notably those, with which Mr. W. H. Carrier and Mr. Frank L. Busey are connected.

Rietschel in his excellent treatise "*Luftungs und Heizungs Anlagen*" gives some values and Meier in his valuable work on the "Mechanics of Heating and Ventilation" gives various values.

The following values of S may be used for steam:—

Steam boilers	2.50
Globe valves and radiators	2.00
Tees (rounded)	1.33
U bends (short)	1.00
Reducers and short ells	0.67
Reducers and long ells	0.42
Long sweep ells	0.33
Gate valves	0.25

LOW PRESSURE STEAM CHART A

The low pressure steam chart enables the graphical solution of Equation 38 and is to be used in the following manner.

Assume a run of straight pipe for delivering 550,000 B. t. u. per hour and losing 30,000 B. t. u. per hour to the air surrounding the pipe. The initial pressure to be 2 lb. per square inch gauge and the final or delivery pressure 1.2 lb. per square inch gauge. The length to be 300 ft.

Then

$$h = 550{,}000 \text{ B. t. u. per hour}$$
$$h + h^1 = 580{,}000 \text{ B. t. u. per hour}$$
$$l = 300 \text{ ft.}$$
$$p^1_2 - p_1 = 0.8 \text{ lb. per square inch}$$

Draw a horizontal line representing 550,000 B. t. u. and indicate at the right until it intersects the vertical line representing 580,000 B. t. u. indicated at the bottom. Through this intersection draw a 45 deg. diagonal as indicated on the chart. Draw a horizontal line representing 0.8 lb. per square inch and indicated at the left until it intersects the vertical line representing 300 ft. indicated at the top. Through this intersection draw a 45 deg. diagonal as indicated on the chart. The intersection of the diagonals represents the pipe diameter. In the foregoing example the size of the pipe is slightly in excess of 3 in. If a 3 in. pipe were used the pressure drop would be in excess of 0.8 lb. per square inch and is obtained as follows.

Where the 45 deg. line passing through the intersection of the 550,000 B. t. u. and 580,000 B. t. u. lines intersects the 3 in. diameter pipe line it will be necessary to draw a 45 deg. parallel to the 45 deg. line passing through the intersection of the 0.8 lb. per square inch and 300 ft. line until it intersects the 300 ft. line, thence horizontally to the right and read 0.87 lb. per square inch as the pressure drop.

LOW PRESSURE STEAM CHART B

The low pressure steam chart enables the graphical solution of equation 40 and is used in the following manner.

Assume a pipe 1.5 in. nominal diameter (internal) for receiving 145,000 B. t. u. per hour with a summation of single resistance factors equal to 4.5.

Then

$$h + h^1 = 145{,}000 \text{ B. t. u. per hour}$$
$$d_1 = 1.5 \text{ in.}$$
$$\Sigma S = 4.5$$

Draw a horizontal line representing 145,000 B. t. u. and indicated at the left until it intersects the vertical line representing 145,000 B. t. u. and indicated at the bottom. Draw a 45 deg. diagonal through this intersection as indicated on the chart until it intersects the 1.5 in. diameter pipe line, then draw a 45 deg. diagonal through this last intersection at right angles to the first until it intersects the vertical line representing $\Sigma S = 4.5$ as indicated at the top and read p^{11}_2 on the horizontal through this intersection as indicated at the right, which in this case is 0.103 lb. per square inch.

Fig. 4 is an assumed layout for overhead low pressure steam heating with the returns left off as they are to handle only the condensation and will not effect the sizes of the steam pipes.

Columns *a, b* and *g* of Table B give values which are generally known before attempting to determine the proper pipe sizes. Values

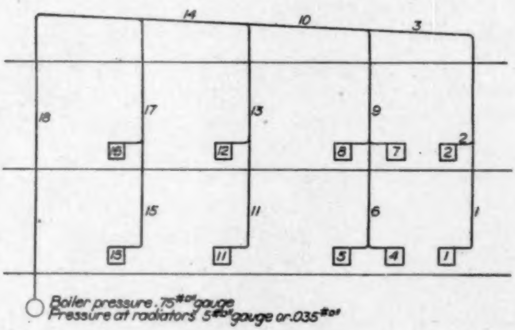


FIGURE 4. EXAMPLE OF OVERHEAD LOW PRESSURE HEATING SYSTEM

of *c* and *f* are assumed and if an assumption turns out to be radically wrong correction must be made after estimating the pipe sizes. Column *h* is so assumed that the working pressure will harmonize well with the limiting pressures p_1 and p^1_2. It may require some adjustment before the figures are acceptable and give fairly uniform pipe sizes. It would not be advisable to put in large pipes and exceedingly small pipes. Column *d* is obtained from Table 2.

The values of *d* must be considered with respect to the single resistances and corrections made. The values given serve their purpose for estimating but before the system is constructed each section must be calculated.

Note that the values of p_1 and p_2 here used are gauge pressures, which is permissible as the difference enters into the equations as used.

CALCULATIONS OF PIPE DIAMETERS

Section 1.

$h = 12{,}000$

$d = \frac{3}{4}$ in.

$\Sigma S = 2.5$

$p^{11}_2 = 0.00635$

$k = 0.78$ for protected pipes.

$l = 23$ ft.

$h^1 = s\,l\,(t_m - t_a)\,k = 0.275 \times 23\,(212 - 70)\,0.78 = 700$

$p^1_2 - p_1 = 0.0236$

$p_2 - p_1 = 0.0236 + 0.00635 = 0.02995$

$p_2 = 0.035 + 0.02995 = 0.06495$

Section 2

$h = 15{,}000$

$d = \frac{1}{2}$ in.

$\Sigma S = 2.5$

$p^{11}_2 = 0.028$

$h^1 = 0.220 \times 6.5\,(212 - 70)\,0.78 = 160$

$l = 6.5$ ft.

$h + h^1 = 15{,}160$

$p^1_2 - p_1 = 0.041$

$p_2 - p_1 = 0.041 + 0.028 = 0.069$

$p_2 = 0.035 + 0.069 = 0.104$

Section 3

$h = 27{,}860$

$d = 1$ in.

$\Sigma S = 3$

$p^{11}_2 = 0.0154$

$h^1 = 0.344 \times 39.5\,(212 - 70)\,0.78 = 1500$

$l = 39.5^1$

$h + h^1 = 29{,}350$

$p^1_2 - p_1 = 0.065$

$p_2 - p_1 = 0.065 + 0.0154 = 0.0804$

$p_2 = 0.104 + 0.0804 = 0.1844$

Section 4

$h = 12{,}000$

$d = \frac{3}{4}$ in.

$\Sigma S = 2.5$

$p^{11}{}_2 = 0.0061$

$h^1 = 0.275 \times 6.5\ (212 - 70)\ 0.78 = 200$

$l = 6.5$

$h + h^1 = 12{,}200$

$p^1{}_2 - p_1 = 0.0066$

$p_2 - p_1 = 0.0066 + 0.0061 = 0.0127$

$p_2 = 0.035 + 0.0127 = 0.0477$

Section 5

$h = 10{,}000$

$d = \frac{1}{2}$ in.

$\Sigma S = 2.5$

$p^{11}{}_2 = 0.0125$

$h^1 = 0.220 \times 6.5\ (212 - 70)\ 0.78 = 160$

$l = 6.5$ ft.

$h + h^1 = 10{,}160$

$p^1{}_2 - p_1 = 0.0176$

$p_2 - p_1 = 0.076 + 0.0125 = 0.0301$

$p_2 = 0.035 + 0.0301 = 0.0651$ which is too large and it will be necessary to use a $\frac{3}{4}$ in. pipe then

$p^{11}{}_2 = 0.0041$

$h^1 = 0.275 \times 6.5\ (212 - 70)\ 0.78 = 200$

$h + h^1 = 10{,}200$

$p^1{}_2 - p_1 = 0.0046$

$p_2 - p_1 = 0.0046 + 0.0041 = 0.0087$

$p_2 = 0.035 + 0.0087 = 0.0437$

Section 6

$h = 22{,}400$

$d = \frac{3}{4}$ in.

$\Sigma S = 1.0$

$p^{11}{}_2 = 0.0082$

$h^1 = 0.275 \times 16.5\ (212 - 70)\ 0.78 = 500$

$l = 16.5$ ft.

$h + h^1 = 22{,}900$

$p^1{}_2 - p_1 = 0.057$

$p_2 - p_1 = 0.057 + 0.0082 = 0.0652$

$p_2 = 0.048 + 0.0652 = 0.1132$

Section 7

$h = 13{,}000$

$d = \frac{1}{2}$ in.

$\Sigma S = 2.5$

$p^{11}{}_2 = 0.021$

$$h^1 = 0.220 \times 6.5\ (212 - 70)\ 0.78 = 160$$
$$l = 6.5 \text{ ft.}$$
$$p^1_2 - p_1 = 0.031$$
$$h + h^1 = 13{,}160$$
$$p_2 - p_1 = 0.031 + 0.021 = 0.053$$
$$p_2 = 0.035 + 0.053 = 0.088$$

Section 8. (Same as 2)

Section 9

$$h = 51{,}220$$
$$d = 1 \text{ in.}$$
$$\Sigma S = 1.5$$
$$p^{11}_2 = 0.024$$
$$h^1 = 0.344 \times 16.5\ (212\text{-}70)\ 0.78 = 630$$
$$l = 16.5 \text{ ft.}$$
$$h + h^1 = 51{,}850$$
$$p^1_2 - p_1 = 0.089$$
$$p_2 - p_1 = 0.089 + 0.024 = 0.113$$

$p_2 = 0.113 + 0.113 = 0.226$ which is too large and it will be necessary to use a 1¼ in. pipe.

$$p^{11}_2 = 0.0078$$
$$h^1 = 0.435 \times 16.5\ (212 - 70)\ 0.78 = 800$$
$$h + h^1 = 52{,}020$$
$$p^1_2 - p_1 = 0.0215$$
$$p_2 - p_1 = 0.0215 + 0.0078 = 0.0293$$
$$p_2 = 0.0293 + 0.113 = 0.1423$$

Section 10

$$h = 81{,}380$$
$$d = 1\tfrac{1}{2} \text{ in.}$$
$$\Sigma S = 0$$
$$p^{11}_2 = 0$$
$$h^1 = 0.497 \times 33\ (212 - 70)\ 0.78 = 1800$$
$$l = 33 \text{ ft.}$$
$$h + h^1 = 83{,}180$$
$$p^1_2 - p_1 = 0.053$$
$$p_2 = 0.053 + 0.184 = 0.237$$

Section 11. (Same as 1)

Section 12. (Same as 2)

Section 13

$$h = 27{,}860$$
$$d = \tfrac{3}{4} \text{ in.}$$
$$\Sigma S = 1.5$$

$p^{11}_2 = 0.019$

$h^1 = 0.275 \times 17\ (212 - 70)\ 0.78 = 540$

$l = 17$ ft.

$h + h^1 = 28{,}400$

$p^1_2 - p_1 = 0.091$

$p_2 - p_1 = 0.091 + 0.019 = 0.110$

$p_2 = 0.110 + 0.104 = 0.214$

Section 14

$h = 111{,}580$

$d = 1\frac{1}{2}$ in.

$\Sigma S = 0$

$p^{11}_2 = 0$

$h^1 = 0.497 \times 29.5\ (212 - 70)\ 0.78 = 1620$

$l = 29.5$ ft.

$h + h^1 = 113{,}200$

$p^1_2 - p_1 = 0.088$

$p_2 = 0.237 + 0.088 = 0.325$

Section 15. (Same as 1)

Section 16

$h = 14{,}000$

$d = \frac{1}{2}$ in.

$\Sigma S = 2.5$

$p^{11}_2 = 0.0243$

$h^1 = 0.220 \times 6.5\ (212 - 70)\ 0.78 = 160$

$l = 6.5$ ft.

$h + h^1 = 14{,}160$

$p^1_2 - p_1 = 0.0351$

$p_2 - p_1 = 0.0351 + 0.0243 = 0.0594$

$p_2 = 0.035 + 0.0594 = 0.0944$

Section 17

$h = 26{,}860$

$d = \frac{3}{4}$ in.

$\Sigma S = 1.5$

$p^{11}_2 = 0.018$

$h^1 = 0.275 \times 26\ (212 - 70)\ 0.78 = 800$

$l = 26$ ft.

$h + h^1 = 27{,}660$

$p^1_2 - p_1 = 0.13$

$p_2 - p_1 = 0.13 + 0.018 = 0.148$

$p_2 = 0.095 + 0.143 = 0.243$

Section 18

$h = 140{,}860$
$d = 1\frac{1}{2}$ in.
$\Sigma S = 4.5$
$p^{11}_2 = 0.103$
$h^1 = 0.497 \times 85\ (212 - 70)\ 0.78 = 4{,}700$
$l = 85$ ft.
$h + h^1 = 145{,}560$
$p^1_2 - p_1 = 0.410$

$$p_2 - p_1 = 0.410 + 0.103 = 0.513$$

$p_2 = 0.325 + 0.513 = 0.838$ which is too large and it will be necessary to use some 2 in. pipe. p_2 must equal 0.750 and p_1 equals p_2 of Section 14 or 0.325. Letting p^{11}_2 remain 0.103 though in fact it will be somewhat less. Then the pressure loss in the straight pipe will be,

$$p^1_2 - p_1 = 0.750 - 0.103 - 0.325 = 0.322$$

Upon inspection it will be noticed that the length of 2 in. pipe will be less than the $1\frac{1}{2}$ in. pipe. One or two trials on the chart will result in the selection of 25 ft. of 2 in. pipe and 60 ft. of $1\frac{1}{2}$ in. pipe for which

$p^1_2 - p_1 = 0.033$ for the 2 in. pipe and
$p^1_2 - p_1 = 0.289$ for the $1\frac{1}{2}$ in. pipe

then

$$p_2 = 0.033 + 0.289 + 0.103 + 0.325 = 0.750$$

Table C gives a summary of the calculations and it will be noted that it was found necessary to increase the sizes of pipes in some cases. It would be well then in estimating to make some allowances for single resistances. The allowance naturally will depend upon the number of resistances encountered in the pipe lines.

Steam chart C enables the determination of the velocity of the steam in pipes, and is self-explanatory.

TABLE A.—WROUGHT IRON AND STEEL PIPE

Adopted Jan. 1, 1913

Standard Weight Pipe									Extra Heavy Pipe			
Nom. Int. Dia.	Actual Int. Dia.	Thick-ness	Actual Ext. Dia.	Size Drill Tap	Th'ds per Inch	Wt. per ft. plain ends	Cu. ft. Int. Per ft. of length	Sq. ft. Ext. Per ft. of length	Actual Int. Dia.	Thick-ness	Wt. per ft. plain ends	Cu. ft. Int per ft. of length
1/8	.269	.068	.405	21/64	27	.244	.00040	.106	.215	.095	.314	.00023
1/4	.364	.088	.540	29/64	18	.424	.00072	.141	.302	.119	.535	.00047
3/8	.493	.091	.675	19/32	18	.567	.00133	.177	.423	.126	.738	.00097
1/2	.622	.109	.840	23/32	14	.850	.00211	.220	.546	.147	1.087	.00161
3/4	.824	.113	1.050	15/16	14	1.130	.0037	.275	.742	.154	1.473	.00295
1	1.049	.133	1.315	1 3/16	11½	1.678	.0060	.345	.957	.179	2.171	.00493
1¼	1.380	.140	1.660	1 15/32	11½	2.272	.0104	.435	1.278	.191	2.996	.0088
1½	1.610	.145	1.900	1 23/32	11½	2.717	.0142	.498	1.500	.200	3.631	.0122
2	2.067	.154	2.375	2 3/16	11½	3.652	.0234	.622	1.939	.218	5.022	.0204
2½	2.469	.203	2.875	2 11/16	8	5.793	.0332	.753	2.323	.276	7.661	.0293
3	3.068	.216	3.500	3 5/16	8	7.575	.0513	.915	2.900	.300	10.252	.0457
3½	3.548	.226	4.000	3 13/16	8	9.109	.0688	1.050	3.364	.318	12.505	.0616
4	4.026	.237	4.500	4 5/16	8	10.790	.0885	1.18	3.826	.337	14.983	.0796
4½	4.506	.247	5.000	4 13/16	8	12.538	.1110	1.31	4.290	.355	17.611	.100
5	5.047	.258	5.563	5 3/8	8	14.617	.1390	1.45	4.813	.375	20.778	.1265
6	6.065	.280	6.625	6 3/8	8	18.974	.201	1.735	5.761	.432	28.573	.1805
7	7.023	.301	7.625	7 7/16	8	23.544	.269	1.995	6.625	.500	38.048	.24
8	8.071	.277	8.625	8 7/16	8	24.696	.355	2.26	7.625	.500	43.388	.317
8	7.981	.322	8.625	8 7/16	8	28.554	.348	2.26				
9	8.941	.342	9.625	9 7/16	8	33.907	.436	2.52	8.625	.500	48.728	.406
10	10.191	.279	10.750	10 15/32	8	31.201	.566	2.81	9.750	.500	54.735	.518
10	10.136	.307	10.750	10 15/32	8	34.240	.560	2.81				
10	10.020	.365	10.750	10 15/32	8	40.483	.548	2.81				
11	11.000	.375	11.750		8	45.557	.660	3.08	10.750	.500	60.075	.634
12	12.090	.330	12.750		8	43.773	.797	3.34	11.750	.500	65.415	.754
12	12.000	.375	12.750		8	49.562	.785	3.34				
13	13.250	.375	14.000		8	54.568	.957	3.665				
14	14.250	.375	15.000		8	58.573	1.106	3.93				
15	15.250	.375	16.000		8	62.579	1.276	4.19				

Table A—Con't. WEIGHTS OF LARGE O. D. PIPE (PER FT. PLAIN ENDS)

O. D. Size	Thickness—Inches											
	¼	5/16	⅜	7/16	½	9/16	⅝	11/16	¾	⅞	1	
14	36.71	45.68	54.57	63.37	72.09	80.73	89.28	97.75	106.13	122.65	138.84	
15	39.38	49.02	58.57	68.04	77.43	86.73	95.95	105.09	114.14	132.00	149.52	
16	42.05	52.36	62.58	72.72	82.77	92.74	102.63	112.43	122.15	141.35	160.20	
17	44.72	55.70	66.58	77.39	88.11	98.75	109.30	119.78	130.16	150.69	170.88	
18	47.39	59.03	70.59	82.06	93.45	104.76	115.98	127.12	138.17	160.04	181.56	
20		65.71	78.60	91.41	104.13	116.77	129.33	141.80	154.19	178.73	202.92	
21		69.05	82.60	96.08	109.47	122.78	136.01	149.15	162.20			
22		72.38	86.61	100.75	114.81	128.79	142.68	156.49	170.22			
24			94.62	110.10	125.49	140.80	156.03	171.17	186.24			
26			102.63	119.44	136.17	152.82	169.38	185.86	202.26			
28				128.79	146.85	164.83	182.73	200.55	218.28			
30				138.13	157.53	176.85	196.08	215.23	234.30			

TABLE B

Section	Heat Units per Hour: For radiators supplied by branch pipes	Loss in previous pipes	Sum of b & c	Losses in pipe branches	Length l	Increase of pres. toward boiler: Assumed lb. per sq. in. per ft. of pipe	Available lb. per sq. in. per ft. of pipe	Gauge Pressure: End lb. per sq. in.	Beginning lb. per sq. in.	Diameter according to Table 2
a	b	c	e	f	g	h	l	P_1	P_2	d
1	12,000		12,000	700	23.0	.0033		.035	.1109	¾
2	15,000		15,000	150	6.5		.0117	.035	.1109	½
3	27,000	850	27,850	1,500	39.5	.0020		.1109	.1899	1
4	12,000		12,000	200	6.5	.0033		.035	.0564	¾
5	10,000		10,000	200	6.5		.0033	.035	.0564	½
6	22,000	400	22,400	650	16.5	.0033		.0564	.1109	¾
7	13,000		13,000	150	6.5		.0117	.035	.1109	½
8	15,000		15,000	150	6.5		.0117	.035	.1109	½
9	50,000	1,350	51,350	650	16.5		.0048	.1109	.1899	1
10	77,000	4,350	81,350	1,800	33.0	.0017		.1899	.2459	1¼
11	12,000		12,000	700	23.0	.0033		.035	.1109	¾
12	15,000		15,000	150	6.5		.0117	.035	.1109	½
13	27,000	850	27,850	550	17.0		.0079	.1109	.2459	¾
14	104,000	7,550	111,750	1,700	29.5		.00183	.2450	.300	1½+
15	12,000		12,000	700	23.0		.0033	.035	.1109	¾
16	14,000		14,000	150	6.5		.0117	.035	.1109	½
17	26,000	850	26,850	800	26.0	.00726		.1109	.300	¾
18	130,000	10,900	140,900	4,600	85.0	.0053		.300	.750	1½

Sum 145,500

SUMMARY OF COMPUTATIONS **TABLE C**

Section	Heat Units per Hour: For the radiator to be supplied by the branch pipes	Loss in the previous pipes	Sum of b and c	Losses in the branch pipes	S	P''_2	Length in feet	Gauge Pressure: End pressure lb. per sq. in.	Beginning pres. lb. per sq. in.	Diameter in.
a	b	c	d	f			g	P_1	P_2	d
1	12,000		12,000	700	2.5	.00635	23.0	.035	.065	¾
2	15,000		15,000	160	2.5	.0280	6.5	.035	.104	½
3	27,000	860	27,860	1,500	3.0	.0154	39.5	.104	.184	1
4	12,000		12,000	200	2.5	.0061	6.5	.035	.048	¾
5	10,000		10,000	200	2.5	.0041	6.5	.035	.044	¾
6	22,000	400	22,400	500	1.0	.0082	16.5	.048	.113	¾
7	13,000		13,000	160	2.5	.0210	6.5	.035	.088	½
8	15,000		15,000	160	2.5	.0280	6.5	.035	.104	½
9	50,000	1,220	51,220	800	1.5	.0078	16.5	.113	.142	1¼
10	77,000	4,380	81,380	1,800	0.0	.0000	33.0	.184	.237	1½
11	12,000		12,000	700	2.5	.00635	23.0	.035	.065	¾
12	15,000		15,000	160	2.5	.0280	6.5	.035	.104	½
13	27,000	860	27,860	540	1.5	.0190	17.0	.104	.214	¾
14	104,000	7,580	111,580	1,620	0.0	.0000	29.5	.237	.325	1½
15	12,000		12,000	700	2.5	.00635	23.0	.035	.065	¾
16	14,000		14,000	160	2.5	.0243	6.5	.035	.095	½
17	26,000	860	26,860	800	1.5	.0180	26.0	.095	.243	¾
18	130,000	10,860	140,860	4,700	4.5	.1030	85.0	.325	.750	1½ with 2 in. connection at boiler 25 ft. long.

TABLE 1.

LOW PRESSURE STEAM

Values of h (h + h¹) for Standard Pipes for Estimating Purposes

Nominal Inside Dia. of Pipe	Value of $\frac{l}{P_2 - P_1}$									
	1,000,000	900,000	800,000	700,000	600,000	500,000	400,000	300,000	200,000	100,000
⅜ in.	.0114 x 10^6	.026x 10^6	.0142 x 10^6	.0163 x 10^6	.0190 x 10^6	.0228 x 10^6	.0285 x 10^6	.0380 x 10^6	.057 x 10^6	.114 x 10^6
½ in.	.0365 x 10^6	.0406 x 10^6	.0456 x 10^6	.0521 x 10^6	.0608 x 10^6	.0730 x 10^6	.0913 x 10^6	.121 x 10^6	.182 x 10^6	.365 x 10^6
¾ in.	.1490 x 10^6	.165 x 10^6	.186 x 10^6	.213 x 10^6	.248 x 10^6	.298 x 10^6	.373 x 10^6	.497 x 10^6	.745 x 10^6	1.49 x 10^6
1 in.	.498 x 10^6	.554 x 10^6	.622 x 10^6	.712 x 10^6	.830 x 10^6	.996 x 10^6	1.24 x 10^6	1.66 x 10^6	2.49 x 10^6	4.98 x 10^6
1¼ in.	1.96 x 10^6	2.18 x 10^6	2.45 x 10^6	2.80 x 10^6	3.27 x 10^6	3.92 x 10^6	4.90 x 10^6	6.54 x 10^6	9.80 x 10^6	19.60 x 10^6
1½ in.	4.24 x 10^6	4.71 x 10^6	5.30 x 10^6	6.06 x 10^6	7.06 x 10^6	8.48 x 10^6	10.6 x 10^6	14.1 x 10^6	21.2 x 10^6	42.4 x 10^6
2 in.	14.8 x 10^6	16.4 x 10^6	18.5 x 10^6	21.1 x 10^6	24.7 x 10^6	29.6 x 10^6	37.0 x 10^6	49.3 x 10^6	74.0 x 10^6	148 x 10^6
2½ in.	36.0 x 10^6	40.0 x 10^6	45.0 x 10^6	51.4 x 10^6	60.0 x 10^6	72.0 x 10^6	90 x 10^6	120 x 10^6	180 x 10^6	360 x 10^6
3 in.	107 x 10^6	119 x 10^6	134 x 10^6	153 x 10^6	178 x 10^6	214 x 10^6	267 x 10^6	356 x 10^6	535 x 10^6	1,070 x 10^6
3½ in.	220 x 10^6	244 x 10^6	275 x 10^6	314 x 10^6	367 x 10^6	440 x 10^6	550 x 10^6	734 x 10^6	1,100 x 10^6	2,200 x 10^6
4 in.	415 x 10^6	461 x 10^6	519 x 10^6	593 x 10^6	692 x 10^6	830 x 10^6	1,040 x 10^6	1,380 x 10^6	2,070 x 10^6	4,150 x 10^6
4½ in.	729 x 10^6	810 x 10^6	912 x 10^6	1,040 x 10^6	1,210 x 10^6	1,460 x 10^6	1,820 x 10^6	2,430 x 10^6	3,640 x 10^6	7,290 x 10^6
5 in.	1,280 x 10^6	1,420 x 10^6	1,600 x 10^6	1,830 x 10^6	2,130 x 10^6	2,560 x 10^6	3,200 x 10^6	4,270 x 10^6	6,400 x 10^6	12,800 x 10^6
6 in.	3,220 x 10^6	3,580 x 10^6	4,020 x 10^6	4,600 x 10^6	5,360 x 10^6	6,440 x 10^6	8,050 x 10^6	10,700 x 10^6	16,100 x 10^6	32,200 x 10^6
7 in.	6,700 x 10^6	7,440 x 10^6	8,380 x 10^6	9,570 x 10^6	11,100 x 10^6	13,400 x 10^6	16,700 x 10^6	22,300 x 10^6	33,500 x 10^6	67,000 x 10^6
8 in.	12,700 x 10^6	14,100 x 10^6	15,900 x 10^6	18,100 x 10^6	21,200 x 10^6	25,400 x 10^6	31,800 x 10^6	42,300 x 10^6	63,500 x 10^6	127,000 x 10^6
9 in.	22,400 x 10^6	24,900 x 10^6	28,000 x 10^6	32,000 x 10^6	37,300 x 10^6	44,800 x 10^6	56,000 x 10^6	74,700 x 10^6	112,000 x 10^6	224,000 x 10^6
10 in.	39,600 x 10^6	44,000 x 10^6	49,500 x 10^6	56,600 x 10^6	66,000 x 10^6	79,200 x 10^6	99,000 x 10^6	132,000 x 10^6	198,000 x 10^6	396,000 x 10^6
11 in.	63,200 x 10^6	72,000 x 10^6	79,000 x 10^6	90,300 x 10^6	105,000 x 10^6	126,000 x 10^6	158,000 x 10^6	211,000 x 10^6	316,000 x 10^6	632,000 x 10^6
12 in.	97,600 x 10^6	108,000 x 10^6	122,000 x 10^6	139,000 x 10^6	162,000 x 10^6	195,000 x 10^6	244,000 x 10^6	325,000 x 10^6	488,000 x 10^6	976,000 x 10^6
13 in.	160,000 x 10^6	178,000 x 10^6	200,000 x 10^6	229,000 x 10^6	267,000 x 10^6	320,000 x 10^6	400,000 x 10^6	533,000 x 10^6	800,000 x 10^6	1,600,000 x 10^6
14 in.	230,000 x 10^6	255,000 x 10^6	287,000 x 10^6	329,000 x 10^6	383,000 x 10^6	460,000 x 10^6	575,000 x 10^6	767,000 x 10^6	1,150,000 x 10^6	2,300,000 x 10^6
15 in.	324,000 x 10^6	360,000 x 10^6	405,000 x 10^6	463,000 x 10^6	540,000 x 10^6	648,000 x 10^6	810,000 x 10^6	1,080,000 x 10^6	1,620,000 x 10^6	3,240,000 x 10^6

TABLE 2

LOW PRESSURE STEAM

* B. t. u. Carried by Standard Pipes Without Heat Loss Along Pipe Per Hour

Nominal Inside Dia. of Pipe Inches	Pressure Drop in lb. per sq. in. for 10 ft. of Pipe									
	.0000100	.0000111	.0000125	.0000143	.0000167	.0000200	.0000250	.0000330	.0000500	.0001000
⅜	107	112	119	128	138	151	169	195	239	338
½	191	202	213	228	247	270	302	348	426	694
¾	386	406	431	462	498	546	611	705	863	1,220
1	706	744	788	844	911	988	1,110	1.290	1,580	2.230
1¼	1,400	1,480	1,570	1,670	1,810	1,980	2.210	2,560	3,130	4,430
1½	2,060	2.170	2,300	2,460	2.660	2,910	3,260	3,760	4.610	6,510
2	3,850	4.050	4,300	4,590	4.970	5.440	6,080	7,020	8.600	12,100
2½	6,000	6,330	6,710	7,170	7,740	8,480	9,490	10,900	13,400	19,000
3	10,300	10.900	11,600	12.400	13,400	14,600	16,300	18,900	23,100	32,700
3½	14,800	15,600	16,600	17.700	19.200	21.000	23,400	27,100	33,200	46,900
4	20,400	21,500	22.800	24,300	26.300	28,800	32,200	37,100	45.500	64,400
4½	27,000	28,500	30,200	32,200	34,800	38,200	42,700	49,300	60,300	85,400
5	35,800	37.700	40,000	42,800	46.200	50,600	56,500	65,300	80,000	113,000
6	56,700	59.800	63,400	67,800	73,200	80,200	89,700	103,000	127,000	179,000
7	81,800	86,300	91,500	97,800	105,000	116,000	129,000	149,000	183,000	259,000
8	113,000	119,000	126,000	134,000	146,000	150,000	178,000	206,000	252.000	356.000
9	150,000	158,000	167,000	179,000	193,000	212.000	237.000	273,000	335,000	473,000
10	199.000	210,000	222,000	238,000	257.000	281,000	315.000	363,000	445,000	629,000
11	251,000	268,000	281,000	300,000	324,000	355,000	397,000	459,000	562.000	795,000
12	312,000	328.000	349,000	373,000	402.000	441,000	494,000	570,000	698,000	988,000
13	400,000	422,000	447,000	478,000	516,000	565,000	633,000	730,000	894,000	1,260,000
14	479,000	505,000	536,000	574,000	619,000	678,000	758,000	876,000	1,070,000	1,510.000
15	569,000	600,000	636,000	680,000	735,000	805,000	900,000	1.040,000	1.270,000	1,800,000

* Divide by 1,000 to obtain approximate pounds of steam per hour.

LOW PRESSURE STEAM

TABLE 2—Con't. * B. t. u. Carried by Standard Pipes Without Heat Loss Along Pipe Per Hour

Nominal Inside Dia. of Pipe, in.	Pressure Drop in lbs. per sq. in. for 10 ft. of Pipe									
	.000100	.000111	.000125	.000143	.000167	.000200	.000250	.000330	.000500	.001000
⅜	338	353	376	404	436	477	534	616	755	1,068
½	604	638	673	720	780	853	954	1,099	1,346	1,908
¾	1,220	1,282	1,361	1,459	1,573	1,725	1,930	2,227	2,727	3,855
1	2,230	2,350	2,490	2,667	2,880	3,120	3,500	4,070	4,990	7,040
1¼	4,430	4,670	4,960	5,270	5,710	6,250	6,980	8,080	9,890	14,000
1½	6,510	6,850	7,260	7,770	8,400	9,190	10,300	11,800	14,500	20,600
2	12,100	12,800	13,600	14,500	15,700	17,200	19,200	22,200	27,100	38,200
2½	19,000	20,000	21,200	22,600	24,400	26,800	30,000	34,400	42,300	60,000
3	32,700	34,400	36,600	39,100	42,300	46,100	51,500	59,700	73,000	103,000
3½	46,900	49,200	52,400	55,900	60,600	66,300	73,900	85,600	105,000	148,000
4	64,400	67,900	72,000	76,700	83,100	91,000	101,000	117,000	143,000	203,000
4½	85,400	90,000	95,400	101,000	110,000	120,000	135,000	155,000	190,000	270,000
5	113,000	119,000	126,000	135,000	146,000	160,000	178,000	206,000	252,000	357,000
6	179,000	189,000	200,000	214,000	231,000	253,000	283,000	325,000	401,000	565,000
7	259,000	272,000	289,000	309,000	331,000	366,000	407,000	470,000	578,000	888,000
8	356,000	376,000	398,000	423,000	461,000	502,000	562,000	650,000	796,000	1,120,000
9	473,000	499,000	527,000	565,000	610,000	670,000	749,000	862,000	1,060,000	1,490,000
10	629,000	663,000	701,000	752,000	812,000	887,000	995,000	1,140,000	1,400,000	1,980,000
11	795,000	846,000	888,000	948,000	1,020,000	1,120,000	1,250,000	1,450,000	1,770,000	2,510,000
12	988,000	1,030,000	1,100,000	1,180,000	1,270,000	1,390,000	1,560,000	1,800,000	2,200,000	3,120,000
13	1,260,000	1,330,000	1,410,000	1,510,000	1,630,000	1,780,000	2,000,000	2,300,000	2,820,000	3,980,000
14	1,510,000	1,590,000	1,690,000	1,810,000	1,950,000	2,140,000	2,390,000	2,770,000	3,380,000	4,770,000
15	1,800,000	1,890,000	2,010,000	2,140,000	2,320,000	2,540,000	2,840,000	3,280,000	4,010,000	5,680,000

* Divide by 1,000 to obtain approximate pounds of steam per hour.

LOW PRESSURE STEAM

TABLE 2—Con't. * B. t. u. Carried by Standard Pipes Without Heat Loss Along Pipe Per Hour

Nominal Inside Dia of Pipe, in.	Pressure Drop in lbs. per sq. in. for 10 ft. of Pipe									
	.00100	.00111	.00125	.00143	.00167	.00200	.00250	.00330	.00500	.01000
⅜	1,070	1,120	1,190	1,280	1,380	1,510	1,690	1,000	2,390	3,380
½	1,910	2,020	2,130	2,280	2,470	2,700	3,020	3,950	4,200	6,040
¾	3,860	4,060	4,310	4,620	4,980	5,460	6,110	7,480	8,630	12,200
1	7,060	7,440	7,880	8,440	9,110	9,880	11,100	12,050	15,800	22,300
1¼	14,000	14,800	15,700	16,700	18,100	19,800	22,100	25,900	31,300	44,300
1½	20,600	21,700	23,000	24,600	26,600	29,100	32,600	37,600	46,100	65,100
2	38,500	40,500	43,000	45,900	49,700	54,400	60,800	70,600	86,000	121,000
2½	60,000	63,300	67,100	71,700	77,400	84,800	94,900	109,200	134,000	190,000
3	103,000	109,000	116,000	124,000	134,000	146,000	163,000	189,000	231,000	327,000
3½	148,000	156,000	166,000	177,000	192,000	210,000	234,000	271,000	332,000	469,000
4	204,000	215,000	228,000	243,000	263,000	288,000	322,000	371,000	455,000	644,000
4½	270,000	285,000	302,000	322,000	348,000	382,000	427,000	493,000	603,000	854,000
5	358,000	377,000	400,000	428,000	462,000	506,000	565,000	653,000	800,000	1,130,000
6	567,000	598,000	634,000	678,000	732,000	802,000	897,000	1,030,000	1,270,000	1,790,000
7	818,000	863,000	915,000	978,000	1,050,000	1,160,000	1,290,000	1,490,000	1,830,000	2,590,000
8	1,130,000	1,190,000	1,260,000	1,340,000	1,460,000	1,590,000	1,780,000	2,060,000	2,520,000	3,560,000
9	1,500,000	1,580,000	1,670,000	1,790,000	1,930,000	2,120,000	2,370,000	2,730,000	3,350,000	4,730,000
10	1,990,000	2,100,000	2,220,000	2,380,000	2,570,000	2,810,000	3,150,000	3,630,000	4,450,000	6,290,000
11	2,510,000	2,680,000	2,810,000	3,000,000	3,240,000	3,550,000	3,970,000	4,590,000	5,620,000	7,950,000
12	3,120,000	3,280,000	3,490,000	3,730,000	4,020,000	4,410,000	4,940,000	5,700,000	6,980,000	9,880,000
13	4,000,000	4,220,000	4,470,000	4,780,000	5,160,000	5,650,000	6,330,000	7,300,000	8,940,000	12,600,000
14	4,790,000	5,050,000	5,360,000	5,740,000	6,190,000	6,780,000	7,580,000	8,760,000	10,700,000	15,100,000
15	5,690,000	6,000,000	6,360,000	6,800,000	7,350,000	8,050,000	9,000,000	10,400,000	12,700,000	18,000,000

* Divide by 1,000 to obtain approximate pounds of steam per hour.

LOW PRESSURE STEAM

TABLE 2—Con't. * B. t. u. Carried by Standard Pipes Without Heat Loss Along Pipe Per Hour

Nominal Inside Dia of Pipe, in.	Pressure Drop in lbs. per sq. in. for 10 ft. of Pipe									
	.0100	.0111	.0125	.0143	.0167	.0200	.0250	.0330	.0500	.1000
⅜	3,380	3,530	3,760	4,040	4,360	4,770	5,340	6,160	7,550	10,680
½	6,040	6,380	6,730	7,200	7,800	8,530	9,540	10,990	13,460	19,080
¾	12,200	12,820	13,610	14,590	15,730	17,250	19,300	22,270	27,270	38,550
1	22,300	23,500	24,900	26,670	28,800	31,200	35,000	40,700	49,900	70,400
1¼	44,300	46,700	49,600	52,700	57,100	62,500	69,800	80,800	98,900	140,000
1½	65,100	68,500	72,600	77,700	84,000	91,900	103,000	118,000	145,000	206,000
2	121,000	128,000	136,000	145,000	157,000	172,000	192,000	222,000	271,000	382,000
2½	190,000	200,000	212,000	226,000	244,000	268,000	300,000	344,000	423,000	600,000
3	327,000	344,000	366,000	391,000	423,000	461,000	515,000	597,000	730,000	1,030,000
3½	469,000	492,000	524,600	559,000	606,000	663,000	739,000	856,000	1,050,000	1,480,000
4	644,000	679,000	720,000	767,000	831,000	910,000	1,010,000	1,170,000	1,430,000	2,030,000
4½	854,000	900,000	954,000	1,010,000	1,100,000	1,200,000	1,350,000	1,550,000	1,900,000	2,700,000
5	1,130,000	1,190,000	1,260,000	1,350,000	1,460,000	1,600,000	1,780,000	2,060,000	2,520,000	3,570,000
6	1,790,000	1,890,000	2,000,000	2,140,000	2,310,000	2,530,000	2,830,000	3,250,000	4,010,000	5,650,000
7	2,590,000	2,720,000	2,890,000	3,090,000	3,310,000	3,660,000	4,070,000	4,700,000	5,780,000	8,180,000
8	3,560,000	3,760,000	3,980,000	4,230,000	4,610,000	5,020,000	5,620,000	6,500,000	7,960,000	11,200,000
9	4,730,000	4,990,000	5,270,000	5,650,000	6,100,000	6,700,000	7,490,000	8,620,000	10,600,000	14,900,000
10	6,290,000	6,630,000	7,010,000	7,520,000	8,120,000	8,870,000	9,950,000	11,400,000	14,000,000	19,800,000
11	7,950,000	8,460,000	8,880,000	9,480,000	10,200,000	11,200,000	12,500,000	14,500,000	17,700,000	25,100,000
12	9,880,000	10,300,000	11,000,000	11,800,000	12,700,000	13,900,000	15,600,000	18,000,000	22,000,000	31,200,000
13	12,600,000	13,300,000	14,100,000	15,100,000	16,300,000	17,800,000	20,000,000	23,000,000	28,200,000	39,800,000
14	15,100,000	15,900,000	16,900,000	18,100,000	19,500,000	21,400,000	23,900,000	27,700,000	33,800,000	47,706,000
15	18,000,000	18,900,000	20,100,000	21,400,000	23,200,000	25,400,000	28,400,000	32,800,000	40,100,000	56,800,000

* Divide by 1,000 to obtain approximate pounds of steam per hour.

LOW PRESSURE STEAM

TABLE 2—Con't. *** B. t. u. Carried by Standard Pipes Without Heat Loss Along Pipe Per Hour**

Nominal Inside Dia of Pipe in.	Pressure Drop in lbs. per sq. in. for 10 ft. of Pipe									
	0.100	0.111	0.125	0.143	0.167	0.200	0.250	0.330	0.500	1.000
⅜	10,700	11,200	11,900	12,800	13,800	15,100	16,900	19,500	23,900	33,800
½	19,100	20,200	21,300	22,800	24,700	27,000	30,200	34,800	42,600	60,400
¾	38,600	40,600	43,100	46,200	49,800	54,600	61,100	70,500	86,300	122,000
1	70,600	74,400	78,800	84,400	91,100	98,800	111,000	129,000	158,000	223,000
1¼	140,000	148,000	157,000	167,000	181,000	198,000	221,000	256,000	313,000	443,000
1½	206,000	217,000	230,000	246,000	266,000	291,000	326,000	376,000	461,000	651,000
2	385,000	405,000	430,000	459,000	497,000	544,000	608,000	702,000	860,000	1,210,000
2½	600,000	633,000	671,000	717,000	774,000	848,000	949,000	1,090,000	1,340,000	1,900,000
3	1,030,000	1,090,000	1,160,000	1,240,000	1,340,000	1,460,000	1,630,000	1,890,000	2,310,000	3,270,000
3½	1,480,000	1,560,000	1,660,000	1,770,000	1,920,000	2,100,000	2,340,000	2,710,000	3,320,000	4,690,000
4	2,040,000	2,150,000	2,280,000	2,430,000	2,630,000	2,880,000	3,220,000	3,710,000	4,550,000	6,440,000
4½	2,700,000	2,850,000	3,020,000	3,220,000	3,480,000	3,820,000	4,270,000	4,930,000	6,030,000	8,540,000
5	3,580,000	3,770,000	4,000,000	4,280,000	4,620,000	5,060,000	5,650,000	6,530,000	8,000,000	11,300,000
6	5,670,000	5,980,000	6,340,000	6,780,000	7,320,000	8,020,000	8,970,000	10,300,000	12,700,000	17,900,000
7	8,180,000	8,630,000	9,150,000	9,780,000	10,500,000	11,600,000	12,900,000	14,900,000	18,300,000	25,900,000
8	11,300,000	11,900,000	12,600,000	13,400,000	14,600,000	15,900,000	17,800,000	20,600,000	25,200,000	35,600,000
9	15,000,000	15,800,000	16,700,000	17,900,000	19,300,000	21,200,000	23,700,000	27,300,000	33,500,000	47,300,000
10	19,900,000	21,000,000	22,200,000	23,800,000	25,700,000	28,100,000	31,500,000	36,300,000	44,500,000	62,900,000
11	25,100,000	26,800,000	28,100,000	30,000,000	32,400,000	35,500,000	39,700,000	45,900,000	56,200,000	79,500,000
12	31,200,000	32,800,000	34,900,000	37,300,000	40,200,000	44,100,000	49,400,000	57,000,000	69,800,000	98,800,000
13	40,000,000	42,200,000	44,700,000	47,800,000	51,600,000	56,500,000	63,300,000	73,000,000	89,400,000	126,000,000
14	47,900,000	50,500,000	53,600,000	57,400,000	61,900,000	67,800,000	75,800,000	87,600,000	107,000,000	151,000,000
15	56,900,000	60,000,000	63,600,000	68,000,000	73,500,000	80,500,000	90,000,000	104,000,000	127,000,000	180,000,000

* Divide by 1,000 to obtain approximate pounds of steam per hour.

TABLE 3

WROUGHT STEAM, GAS AND WATER PIPES

	d						
Nominal Internal Diameter in Inches	Approximate Internal Diameter in Inches	Log d	Log (d^2)	Log (d^4)	Log $[144(12.55d)^4]$	Log (d^5)	Log $(10d)^5$
⅛	.269	9.42975—10	8.85950—10	7.71900—10	4.27192	7.14875—10	2.14875
¼	.364	9.56110—10	9.12220—10	8.24440—10	4.79732	7.80550—10	2.80550
⅜	.493	9.69285—10	9.38570—10	8.77140—10	5.32432	8.46425—10	3.46425
½	.622	9.79379—10	9.58758—10	9.17516—10	5.72808	8.96895—10	3.96895
¾	.824	9.91593—10	9.83186—10	9.66372—10	6.21664	9.57965—10	4.57965
1	1.049	.02078	.04156	.08312	6.63604	.10390	5.10390
1¼	1.380	.13988	.27976	.55952	7.11244	.69940	5.69940
1½	1.610	.20683	.41366	.82732	7.38024	1.03415	6.03415
2	2.067	.31534	.63068	1.26136	7.81428	1.57670	6.57670
2½	2.469	.39252	.78504	1.57008	8.12300	1.96260	6.96260
3	3.068	.48686	.97372	1.94744	8.50036	2.43430	7.43430
3½	3.548	.54998	1.09996	2.19992	8.75284	2.74990	7.74990
4	4.026	.60487	1.20974	2.41948	8.97240	3.02435	8.02435
4½	4.506	.65379	1.30758	2.61516	9.16808	3.26895	8.26895
5	5.047	.70303	1.40606	2.81212	9.36504	3.51515	8.51515
6	6.065	.78283	1.56566	3.13132	9.68424	3.91415	8.91415
7	7.023	.84652	1.69304	3.38608	9.93900	4.23260	9.23260
8	8.071	.90693	1.81386	3.62772	10.18064	4.53465	9.53465
8	7.981	.90206	1.80412	3.60824	10.66116	4.51030	9.51030
9	8.941	.95139	1.90278	3.80556	10.35848	4.75695	9.75695
10	10.192	1.00826	2.01652	4.03304	10.58596	5.04130	10.04130
10	10.136	1.00587	2.01174	4.02348	10.57640	5.02935	10.02935
10	10.020	1.00087	2.00174	4.00348	10.55640	5.00435	10.00435
11	11.000	1.04139	2.08278	4.16556	10.71848	5.20695	10.20695
12	12.090	1.08243	2.16486	4.32972	10.88264	5.41215	10.41215
12	12.000	1.07918	2.15836	4.31672	10.86964	5.39590	10.39590
13	13.250	1.12222	2.24444	4.48888	11.04180	5.61110	10.61110
14	14.250	1.15381	2.30762	4.61524	11.16816	5.76905	10.76905
15	15.250	1.18327	2.36654	4.73308	11.28600	5.91635	10.91635

TABLE 4

WROUGHT STEAM, GAS AND WATER PIPES

	D	d	t							
Nominal Internal Dia. in Inches	External Diameter in Inches	Approximate Internal Dia. in Inches	Approx. Thickness in Inches	$\frac{\pi D}{12}$	d^2	$\frac{\pi d^2}{4 \times 12^2}$	d^4	$144\,(12.55\,d)^4$	d^5	$(10\,d)^5$
⅛ in.	.405	.269	.068	.106	.07236	.000396	.005236	18,703	.001408	140.8
¼ in.	.540	.364	.088	.141	.1325	.000722	.017555	62,707	.00639	639
⅜ in.	.675	.493	.091	.177	.2430	.001326	.059065	211,000	.02912	2,912
½ in.	.840	.622	.109	.220	.3869	.002111	.1497	534,700	.09310	9,310
¾ in.	1.050	.824	.113	.275	.6790	.003703	.4610	1,647,000	.3999	37,900
1 in.	1.315	1.049	.133	.344	1.1004	.006002	1.2110	4,326,000	1.270	127,003
1¼ in.	1.660	1,380	.140	.435	1.9044	.01038	3.627	12,960,000	4.943	494,300
1½ in.	1.900	1.610	.145	.497	2.5921	.01414	6.719	24,000,000	.1082	1,082,000
2 in.	2.375	2.067	.154	.622	4.2725	.02330	18.25	65,200,000	37.73	3,773,000
2½ in.	2.875	2.469	.203	.753	6.096	.03325	37.16	132,700,000	91.75	9,175,000
3 in.	3,500	3.068	.216	.916	9.413	.05137	88.60	316,500,000	271.8	27,180,000
3½ in.	4.000	3.548	.226	1.047	12.59	.06870	158.5	566,000,000	562.2	56,220,000
4 in.	4.500	4.026	.237	1.178	16.21	.08840	262.7	938,400,000	1.058	105,800,000
4½ in.	5,000	4.506	.247	1.309	20.30	.1106	412.2	1,473,000,000	1,858	185,800,000
5 in.	5.563	5.047	.258	1.456	25.47	.1390	648.8	2,318,000,000	3,275	327,500,000
6 in.	6.625	6.065	.280	1.734	36.78	.2007	1,353	4,833,000,000	8,206	820,600,000
7 in.	7.625	7.023	.301	1.996	49.32	.2691	2,433	8,690,000,000	17,080	1,708,000,000
8 in.	8.625	8.071	.277	2.258	65.14	.3552	4,243	15,160,000,000	34,250	3,425,000,000
8 in.	8.625	7.981	.322	2.258	63.70	.3491	4,057	14.490,000,000	32,380	3,238,000,000
9 in.	9.625	8.941	.342	2.520	79.94	.4360	6.391	22,830,000,000	57,140	5,714.000,000
10 in.	10.750	10.192	.279	2.814	103.9	.5662	10,790	38,540,000,000	110,000	11,000.000,000
10 in.	10.750	10.136	.307	2.814	102.7	.5604	10,560	37,710,000,000	107,000	10,700,000,000
10 in.	10.750	10.020	.365	2.814	100.4	.5480	10,080	36,010,000.000	101,000	10,100,000,000
11 in.	11.750	11.000	.375	3.076	121.0	.6608	14.640	52,300,000,000	161,000	16,100,000,000
12 in.	12.750	12.090	.330	3.338	146.2	.7969	21.370	76.320,000,000	258,300	25,830.000.000
12 in.	12.750	12.000	.375	3.338	144.0	.7856	20,740	74,070,000,000	348,800	24,880,000,000
13 in.	14.000	13.250	.375	3.665	175.6	.9570	30,820	110,100,000,000	408,400	40,840,000,000
14 in.	15.000	14.250	.375	3.927	203.1	1.106	41,230	147,300.000,000	587,600	58,760.000,000
15 in.	16.000	15.250	.375	4.189	232.6	1.276	54,085	193,200,000,000	824,800	82,480,000,000

APPENDIX

The value of the coefficient "f" as used by various authorities and as computed is as follows:

Authority	*"f"*
Geipel and Kilgour	.033
Gutermuth	.030
Haropsley	.028
Martin	.0265
Hurst	.0264
Unwin	$.0106\left(1 + \frac{3.6}{d}\right)$
Carpenter	$.0104\left(1 + \frac{3.6}{d}\right)$
Babcock	$.0104\left(1 + \frac{3.6}{d}\right)$
Eberle (Zeitschrift des Veriens deutscher Ingenieure, 1908)	.0201
Fisher (S. Handbuck der Architektur III 4)	.0294
C. Bach and R. Stucke (A.S.M.E. Journal, Sept., 1913)	.0335
Meier's (low pressure)	$\frac{.03825}{v^{.03}\, d^{.16}}$
Meier's (high pressure)	$\frac{.03825}{v^{.05}\, d^{.20}}$
Rietschel (Uses Eberle's value for high pressure)	.0201
Rietschel (Uses Fisher's value for low pressure)	.0294

DISCUSSION

Mr. Bolton: I met a man who had a pipe 4,000 feet long, to supply steam under moderate pressure, no steam at all came out at the other end, because the surface was simply condensing it all. Most of our tables and figures seem to be based upon a condition which is ideal, so that those losses are within a certain minimum amount, which is assumed here, and they do not seem to regard the fact, which I believe we have yet to learn, that the conditions for condensation vary inside the pipe itself, and according to the speed of the steam in the pipe.

I have had an illustration of that fact, which I hope to lay before the Society at a later date. In the case of an extended test, when in a system of piping, the condensation inside the piping increased in volume, not merely relative to the amount of steam, but in total volume, as the amount of steam passed

through the pipe decreased; in the units the less steam that was passed through the pipe, the more condensation came from the pipe.

Now we have to decide for ourselves what is causing that condition.

As regards the question of insulating pipes, I believe Professor Diederichs has been making a study and stated that there came a point where additions to the covering laid over a pipe became a loss, instead of a gain.

We will ask him on some occasion to give us information on these results. Bye and bye, I think we may learn something about how many B.t.u.'s, can be pushed through a pipe of given length. I would like to make one criticism of the paper I just heard,—that the use of 10 feet seems to be too short a basis for computation. I would like to see that replaced by the old standard figure of 100 feet, we have long been accustomed to seeing.

Mr. Davis: The question of covering has been taken up here. I know that Professor Harding, a member of this society, has done a great deal of work in Pittsburgh, on testing covers, and I think he probably has as complete a set of data on that as any man in the country, and I believe he would give it to the Society if he were asked.

Mr. Donnelly: Mr. President, I am very interested in the flow of steam in pipes. One of the first things I did, after I became a member of the Society, and got started, was to try and get out something along that line, and I believe some tables that I presented to the Society have come into more or less general use.

I found as far as the heating is concerned, there are two problems, one is the flow of steam in the pipes within the buildings themselves, and the flow of steam in pipes from one building to other buildings, which were more exposed than those within the buildings themselves. The drop in pressure in steam is not as important to my mind as the possibility of the good drainage for the condensation, producing what we commonly call good circulation. Therefore, high drops in pressures, within the building itself, are not often met.

If we pipe low pressure steam for a long distance between buildings, shall we make any difference in the sizes of pipes from those within the building? It is my practice to design all buildings on the same scale of piping, so that wherever it is

placed in the plant, it would have the same drop in pressure as that in the building.

But to figure the steam main from one building to another, is a different problem, especially if it has been piped for steam to be conveyed at low pressure. Where the steam is conveyed between the buildings at high pressure, and reduced at the building, we have large drops in pressure.

Data regarding the drop in pressure for steam pipes, where the drop is of any considerable amount, I have never seen published. Professor Kent in his handbook, states that the formula of $\sqrt{2\,gh}$ for flow of steam through an orifice, is only correct for small differences in pressure. The same thing obviously might be said about the $\sqrt{2HG}$ being correct, for only small differences of pressures in a pipe. I have never seen it stated clearly enough, so that members could get hold of it in that way. Therefore, the formulas, which are here figured, for large drops, and long runs, do not apply. The drop in pressure is a great deal more than the formula gives, applied to some of the thermo dynamics, of steam.

Mr. William Kent: When an engineer is designing a low-pressure steam-heating system, about the only problem he has to solve relating to flow of steam in each run of pipe that he intends to use is the following: What commercial size of pipe shall be used to carry a given number of pounds of steam per hour with a given drop in pressure? He may solve it by means of the commonly accepted formula $W = c\sqrt{\frac{w\,(p\text{-}p_2)\,d^5}{L}}$ in which W = weight of steam in pounds per minute, c = an experimental coefficient, W = density of steam in pounds per cubic foot, p_1 and p_2 pressure in pounds per square inch at the two ends of the pipe, d the actual internal diameter of the pipe in inches and L the length in feet. To solve the problem in this way it is necessary to refer to tables to find values of W and c, and of actual diameters corresponding to nominal sizes of pipe, also to tables of squares and of fifth powers. It is much easier to refer to a single table in which most of the calculations are already made, such as the one given by the writer in the Transactions for 1907 (also in the Mechanical Engineers' Pocket book, 8th edition, page 670). In fact, for pressures between atmosphere and 3 lbs. gauge the following brief table is all that is necessary.

Flow of low pressure steam in pipes, pounds per hour, calculated for a drop of 1 pound per 1,000 feet of length:

Nominal diam. of pipe in.	Verner 3 lbs.	Kent 0.3 lbs.	3.36	Babcock Multiply figures in 3d & 4th col. by
½	6.2	4.2	4.6	
¾	12.5	9.7	10.5	
1	24.0	19.0	20.7	0.90
1¼	45.6	40.1	43.7	
1½	67.1	61.4	66.8	
2	125	120.8	131.6	0.99
2½	196	195.7	213.2	
3	337	345.5	376.4	1.05
3½	483	505.3	550.5	
4	663	701.4	764.4	1.09
4½	880	938.7	1023	
5	1164	1252	1364	
6	1844	2011	2192	1.15
7	2668	2936	3199	
8	3667	4082	4448	
9	4872	5462	5951	1.20
10	6479	7314	7968	
12	10176	11550	12594	1.24

For any other drop multiply the figures given by the square root of the drop per 1,000 feet. Example: if the drop is 9 pounds per 1,000 feet the figures of flow are to be multiplied by 3.

The figures in the second column are obtained from Mr. Verner's table by dividing the B.t.u. carried with 1 pound drop per 100 feet of pipe by 10,000 and adding 3 per cent., in order to convert his figures into equivalent pounds of steam (assuming the latent heat at 970 B.t.u.), carried with 1 pound drop in 1,000 feet. The figures in the third and fourth column are taken from the table published by the writer in 1907, and are computed from the formula given above with the following values of C.

Diam. of pipe	½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12
C =	36.8	42	54.3	48	50	52.7	54.8	56.2	57.1	57.8	58.3	58.7	59.5	60.2	60.9	61.3	61.7	62.1

Mr. Babcock's formula, published in the Babcock & Wilcox Co.'s book "Steam," gives values which differ from those in the third and fourth columns by the ratios given in the fifth column. Mr. Verner's figures for the larger size of pipe are much lower than the writer's values and much lower than Babcock's.

Mr. Verner's figures are based on the assumption of a constant value of the coefficient of friction. It is well known that the value of this coefficient varies with the diameter of the pipe and probably also with the velocity.

It is to be regretted that Mr. Verner has spent such a vast amount of time and labor in producing extensive tables and logarithmic charts which are less reliable, and vastly less convenient than the simple tables already in use. The engineer never needs to figure the British thermal units carried by a pipe, always using the pounds of steam instead, and he has no need of logarithmic charts when the information they convey is more easily found by reference to more convenient tables.

Mr. Verner: Professor Kent's discussion is quite opportune and allows me to bring out several points which though touched upon in the paper need some emphasis.

The equation quoted by Professor Kent is obtained in a similar manner to the method I have used in arriving at equation 38. It will be noted however, that equation 39 contains the value (w^1) which represents the equivalent weight of steam lost in the pipe line as heat units and in many low pressure heating systems is an item of considerable importance.

The quantities used in the tables and charts are expressed in B.t.u. per hour which is the generally accepted measure for estimating heat transmission of walls and heating apparatus. I have found that it is much more convenient in designing low pressure heating systems to carry all quantities in B.t.u. until I reach the source of heat supply.

Table 2 will be found very convenient to use as explained relative to figure 4 and table B, and is close enough for estimating purposes as brought out by table C which is a result of computation.

I fail to see where Professor Kent is justified in using coefficients obtained from the widely accepted formula of Darcy's for the flow of water and applying them to steam. He states in his "Mechanical Engineers' Pocket Book": "In the absence of direct experiment, these coefficients are probably as accurate as any that may be derived from formulae for flow of water."

The expressions used by Rietschel and Fisher and others agree closely among themselves and appear to be the most accurate for the range of diameters and velocities met in low pressure heating work. The value of "f" used by Rietschel is the same as used by Fisher or .0294 and is applied to pipes ranging from ⅜ inch to 12 inches diameter.

In reply to Professor Kent's expression of regrets as to the amount of time and labor spent in producing the tables and charts I am able to state that they have already more than paid

for themselves—for instance, assume a 100 square foot radiator giving up 250 B.t.u. per square foot per hour. A pipe 50 feet long is to supply the radiator with steam at 0.1 pounds per square inch. The pressure entering the pipe is 0.2 pounds. What size pipe is necessary allowing 10 per cent. lost in transit? The pressure drop in the pipe per 10 feet is .02 pounds, the B.t.u. at the radiator desired is 25,000 and at the entrance of the pipe 10 per cent. more or 27,500. From table 2 for .02 pounds drop in 10 feet it is evident that a 1-inch pipe is required. What would be the pressure drop if a 2-inch pipe were used? From table 2 a 2-inch pipe is good for 27,100 B.t.u. at .0005 pounds drop for 10 feet or .0025 pounds drop in the 50 feet.

The possibilities of logarithmic charting as a method of calculation are only beginning to be appreciated. The slide rule was looked upon at first with some hesitancy. The graphical method should add materially to the efficiency in engineering by encouraging more care in the solution of problems.

I would like to say a word more. I appreciate very much what has been brought out by this paper. That is one reason why I gave it—I wanted it cut to pieces. And I hope that they will keep on cutting it, and I hope it goes into the record with some scars on it, and I hope it will be brought up again. We need work on this subject. We have good data relative to the flow of air submitted by Mr. Busey and others. I am going to give some time to find the values for steam, and I hope somebody else will be doing the same thing, so that we can compare results.

CCCXL

HEATING AND VENTILATING IN GERMANY.

BY H. W. E. MUELLENBACH, HAMBURG

For heating several rooms from one place the term "central heating" has been introduced in this country. The practice of building central heating plants is old. Belonging formerly to the building trade, it developed in Germany an independent technique during the first quarter of the previous century.

Originally, hot-air heating systems were used, depending upon the natural buoyancy of the air. They were carefully planned according to the physical laws of air currents for which known rules had been ascertained. These requirements called for large transverse sections for the channels for air currents which rendered it difficult to build them in walls or under ceilings. Tin pipes were never used. Later a kind of low-pressure steam heating system from America was utilized and a kind of hot-water heating (Perkins system) from England, with coils distributed in a number of smaller warm air chambers at the bottom of the warm air flue and thereby doing away with lateral channels.

These systems of "indirect" air heating by warm water or steam postponed, until the present, hot-air furnaces which now find more consideration. Warm water heating was introduced in the middle of the last century. The first heating by means of local radiators was used for heating greenhouses and for public offices and the better dwellings. The Perkins' heating system was displaced. As radiators, and separate sets of coil pipes came into use soon after, cast iron indirect radiators came into use.

About 1880 two German engineers, Bechem and Post, introduced a new heating system that partly revolutionized the existing central heating one and led to a new and active development. This system, known as the B and P, manifested itself first as

low-pressure steam heating with local radiators under thick mantels of felt (insulating covers). These insulating covers had an opening above and below, the upper provided with a slide. Often the mantels were furnished with fresh-air openings through the wall. For heating the room, the stream of warm air issuing from the top served to heat the room without the radiation being felt. The radiators had only one pipe connection from the steam generator which also took away the condensed water and returned it to the boiler.

The inventors accomplished the two-fold purpose of using the generated steam to feed a low-pressure motor for electric illumination of the house and for heating. The insulation mantels were to introduce the fresh air to the ascending warm-water heat and also to prevent any annoyance from the radiating heat. They, however, were found to be breeding places for all kinds of dirt, and the one-pipe system for conducting the steam did not suffice for more extended plants. The simultaneous employment of the steam for producing electric energy and heat was without practical success.

The principal legacy from this system is the open low-pressure steam heating system of similar construction to the warm-water heating, boilers, radiators with double connecting lines and open to the air. With the advent of the wholesale manufacture of these materials after the American pattern, the activity of the heating engineer was merged into that of heating contractor, who assembles the various parts of the plant of special manufactures and contents himself with the work of installation only.

Large factories for the production of material for central heating plants have arisen in Germany in which the general manufacture of parts such as radiators and heating boilers predominate. The larger manufacturers of these specialties have formed a general selling agency (Radiator syndicate) to maintain prices and market the goods which in 1912 disposed of about 1,250,000 sq. m. of finished radiators. The radiators scarcely differ from the well-known American model. The boilers have undergone a recasting from the American model, suitable for firing with coke that prevails in Germany. Recently brown coal and peat as fuels are receiving considerable attention.

The boiler manufacturers are busying themselves in designing special construction to burn slack and dirty coal with underfeed stokers of a kind very similar to those of Surell & Co., New

York. Brown coal in Germany is gaining increased use as briquettes, the effect of which in firing must be further studied. The former practice, to build boilers of not over 15 to 20 sq. m. heating surface for a hearth is abandoned for the introduction of large boilers of about 40 sq. m. or displaced by a chain of boilers in which the members are arranged in rows side by side which, individually of small hearth space, are expanded in combination to about 275 sq. m. The earlier customary grouping of a large number of smaller separate boilers near one another has decreased.

This is evidence of the fact that cast-iron boilers in Germany are carefully poured from the best material and reliably assembled so that a reserve in case of trouble from accident is not necessary. Similarly along this line of manufacturing, plants have opened up in Germany for turning out boiler fittings and have developed into large enterprises. The various fittings are classed as valves, cocks, conductors for condensed water, general fittings, etc.

An especially lively constructive activity exists in the market for heat regulating apparatus which depends, in hot-water heating mostly on the laws of heat expansion and in steam heating on the utilization of the increase in pressure.

To summarize: The German central heating scheme prefers at present hot water and low-pressure steam heating for which there is available good construction and a technical fabrication of a high order.

Hot air heating is little used in private dwellings. In municipal buildings, hot-air heating forced circulation with its general application of mechanical ventilators grows in favor. Prosperous contractors as a rule, make long time arrangements on their special plants which serve to increase their output. For increased business, special rebates on the original price is offered. By this method the interest on the part of the contractor to increase as far as possible his yearly consumption of material and thus increase the output of the manufacturer. This refers especially to the private building industry where systemizing in the execution of central heating has become a rule. In this the open tank warm-water heating system is easily the most important. The demands of the authorities as to heating and ventilating public buildings have developed in different ways. The regulations for technical heating equipment limit themselves to simple heating or adequate means for heating and ventilating

according as the deciding authority agrees. The best and most widely known of municipal regulations is "The Directions for the Erecting and Manufacturing of Central Heating and Ventilating plants in Prussian State Buildings."

In the technical part of these rules, a temperature of 22 deg. C. is indicated for hospitals; 20 deg. C. for office and living rooms; 18 deg. C. for halls and assembly rooms and 10 to 18 deg. C. for other rooms according to their use. The calculation as to the change of air is stipulated per person and has to be 10 cu. m. in sleeping cells and in rooms for general imprisonment, 15 to 22 cu. m. in single cells of prisoners; 20 cu. m. in congregating rooms; 10 to 15 cu. m. in school rooms, according to the age of the pupils. Halls and staircases should receive hourly from a half to a double change of air according to use.

As to the need of ventilation in hospitals, the rules say nothing, but state that the "question in every individual case is to be considered in connection with the construction of the institution." Where heat given off by inmates or by illumination is to be taken into consideration, a special computation for change of air is to be made. In water closets and other rooms, provision must be made to ventilate independently from the other rooms and for a five-fold or at least a three-fold change of air.

The limits in the temperature outside for a complete change of air are further mentioned in these rules. Where special radiators for warming the fresh air are needed, the heaters in the rooms must be enlarged to provide the necessary heat. For estimating the heat loss in space the regulations stipulate in heat units, the loss which the enclosing walls suffer, according to the material and thickness of the walls, for 1 deg. difference in temperature and 1 sq. m. of surface. Besides for locations according to the compass and for the assumed method of heating, special additional provisions are to be made. In a formula, the rules give an example of "reckoning hourly heat losses" according to which these can be uniformly ascertained and recorded. The formula filled out is then attached to the bid in order to serve as a basis for a comparison of the different applications.

This book, "Rules for Prussian State Buildings" goes on the hypothesis that contractors in working out a heating project with technically educated heating engineers, or as such themselves, will endeavor to make the directions more definite so as to bring these estimates to a basis for comparison,—to make definite their details. In this way the competing firms are sad-

dled with preliminary technical work which involves much trouble and expense without any certainty of receiving any compensating recompense. The Rules provide therefore in detailed terms for the possibility of earnest competitors being without recompense, after turning in their preliminary work, by authorizing a payment of between 2.8 and 1.7 per cent. of the estimate. In such a case the number of bidders is limited according to the extent of the project.

On the other hand, city authorities have many times distributed to their Board of Works their own ideas on their heating contracts, with figures technically the outlines and then, make final plans and specifications; it is then awarded to the best bidder in public competition. This offers the local artisan and the small contractor a favorable opportunity to obtain large contracts. In other cases, it happens that the authority that decides the contract gives it to a contractor for a lump sum and leaves it to him to further let the stipulated heating contracts. In general the low bid as the deciding factor is more potent than good execution.

The German central heating industry at present ranks scientifically and technically high, but as regards economy and profit, the situation is less favorable because of the reckless competition among the contractors. The fault lies with the exactions of industrial boundaries and the consequent lack of a practical, common interest among the professional, industrial and mechanical circles, which more and more strive for the taking over of the central heating business. The separation, now well advanced, between the matter of supplying material by organized specializing plants and the erection of heating plants at definite places fosters this desire for contracting for which principally the pipe laying and joining continues with tools and grips the same as the erector for gas and water plants uses them.

Against this stands the lifting of the heating and ventilating business to a technical science which found its development through Professor Rietschel, who to-day a large number have followed to the technical high school. The work of Rietschel began with the laying down of rules for estimating the necessary space to be heated and a general estimate of the local radiator surface and heat production to cover the estimated loss of heat. With special thoroughness the transportation of the heating medium, water or steam, through a system of pipes was carried out by careful calculation, and formulas were established

by which to estimate the most favorable inner diameter of the pipe for the movements of a given quantity of heat through definite lengths. The labors of Rietschel were supported by the state building authorities of Prussia and at their suggestion were collected in a manual which found wide circulation.

The fundamental work of Rietschel has received, in the edition which followed quickly, a deserved expansion and appreciation. To the greater part of the central heating contractors in private buildings this is not of much value. They satisfy themselves with the original rules for estimating the heat losses by means of change of space. Special provisions for ventilating heated rooms are not required for heating dwellings and are also not reckoned.

If the heating proposition is to be figured, the architect or building chief delivers the plans and indicates the rooms that are to be heated. Very often the location of the radiators in the various rooms is designated by the designers and the desired inside temperature indicated. The coldest outside temperature is put at—20 deg. C.

The work of heat technique begins with the surveying of the rooms with the estimation of the square space according to the kind of material and its strength. The estimated totals are tabulated. Further, the difference in temperature in front and back of the wall is multiplied by the value of the unit of heat loss (heat coefficient), according to Rietschel and the number obtained multiplied by the surface. The estimated loss of heat in heat units is entered in the column of the scheme and added after all the calculations for all the surfaces of the room made. To these heat losses are added definite things, among them something for change of air although the air circulates only naturally (ventilation by pores). This mode of reckoning assumes more persistence and reliability as well as special mathematical knowledge.

With the estimation of the heat losses for a given heating outfit, the computing part of a bid on the technical side is settled. For the giving off of heat from local radiators fixed values referred to the surface unit are at hand and for estimating the diameter of the pipes tables are furnished which in growing numbers are to be obtained all ready printed and illustrated in many cases by examples.

Of special prominence there are two pocket manuals: Klinger's Calendar for Heating and Ventilating Technique, and Reck-

nagel's Calendar for Health Technique. This competition of almost all industrial classes for the awarding of central heating is made possible and easy by means of the uniform equipment, supplied by the manufacturers for open tank hot-water heating, or for low-pressure steam heating.

This equipment consists of boilers, radiators and expansion vessels. In addition there is a draft regulator for the boiler, a regulating and stop valve for each radiator. The stop valve has, as a rule, a double valve cylinder. The cylinders are moved in and out by a spindle. When the testing of the system takes place, the entrance pressure in the respective radiators is equalized by the fundamental cylinder (steam dome) so that the heating medium passes through all the radiators at equal pressure. When this is accomplished, the main regulator is set while the automatic regulating remains movable by a lever or wheel in the circumference of a scale from "open" to "shut."

This fundamental adjustment serves to equalize the unavoidable difference in the motion of the heating medium caused by the grading down of the sides of the pipes for which only definite pipe diameters are considered as they are bought on the market.

The hot-water radiators receive, as a rule, a double stop-off valve. For low-pressure steam the radiators besides are mostly furnished with a damming valve in the conductor for the condensed water. The condensing systems have, as a rule, besides the condensed water gauge a common ventilating duct which has an outlet to the open air or into a chimney. Ventilating conduits are also, if possible, provided in hot-water heating with air dampers to regulate in case of necessity.

In this method of construction the radiators in the low-pressure steam system are credited with the giving off heat of 700 heat units. For low pressure warm water heating the radiators on the contrary give off only 450 heat units, or as the proposition is commonly stated "low-pressure steam needs only 3/5 of the heating surface of warm water," together also with only 3/5 of the material in diameter in radiators and connecting pipes. Viewed in this way low-pressure steam is a cheaper substitute for the formerly preferred warm water heating.

Automatic vacuum heating which combines the advantages of warm water heating (general regulating and moderate heating radiators) with the advantages of the low-pressure steam heating (quick action in heating and cooling) should for Ger-

many be the most advantageous mode of heating because of climatic conditions, but it is as good as unknown. With intelligent propaganda this method of heating, much used in America, must also find successful introduction into Germany.

A special kind of warm-water heating has found in Germany and neighboring countries extensive use—kitchen range heating. The plural family dwellings of large cities, which often offer shelter to thirty or more families, have contributed to this. The attempt was made to give these houses central warm-water heating (rarely low-pressure steam), this heating to be managed by the owner and the cost to be met by meters. From this point of view this way of heating does not differ much from the common ones in equipment. The plan labors under the difficulty of a just apportionment of the heating cost through the want of proper controlling apparatus like gas and water measuring.

Besides it is difficult to satisfy by means of such a clumsy central system, the demands for heat in the intervening time between fall and winter and from winter to spring. But by the heating obtained from the kitchen range in each separate apartment, the owner is relieved of the anxiety regarding the heat and the freedom arising from the fact that the tenant is master of his own system corresponds now with the progress of the times. Besides a kitchen range is always much to be preferred for hard fuel.

The mechanical systematizing of the greater part of the central heating industry has manifestly found much opposition among the scientific contractors who see therein a hindrance to the progressive development of the heating profession. A definite direction has been given to this in the aims of the union of the German Central Heating Manufacturers who particularly strive to raise the standard in the central heating business but also to demand and obtain a correspondingly higher recompense for the work preparatory to its execution. In 1898 prominent firms of the heating profession had formed an economic combination and established the union which then obtained numerous members. The union has amplified and made obligatory on its members the Prussian rules for figuring necessary heat. Further the union should be credited with the fact that the Prussian authorities decided upon partial recompense for the unsuccessful bidders and limited the number of competitors. The union also established standards for pipe and patterns which found acceptance with the authorities.

The experimental station established by Professor Rietschel in Charlottenburg for heating and ventilating was materially aided by the union. Its principal task—to bring into recognition industrially improved heating and ventilating technique—has not been accomplished. It is doubtful whether this aim can be realized under the advancing separation, already mentioned, between the manufacturing plants and the installation contractors. The desire to bring to fruition simultaneously the technical ability of its members in planning and execution explains the discouraging attitude of the union towards the standing of the consulting engineers for heating and ventilating which has developed but little in Germany.

Alongside this union there exists in Germany a "free alliance of heating and ventilating experts" who assemble in a congress every two years in order to influence the improvement of heating and ventilating appliances in a technical, scientific and sanitary direction by communication of the results of investigations and by instruction in suitable execution. Neither alliance has succeeded in forming the kernel of a technical association which should develop into a union such as the American Society of Heating and Ventilating Engineers.

Alongside of the industrial aspect of the German heating and ventilating profession, there runs with marked delimitation the activity of the wholesale trade in heat technique. These activities are taken care of by a staff of professional engineers who, in an advisory capacity, assist the building authorities to prepare for their projects, instructions of standard adaptation.

The results would have been different if a comparative statement of the calculations were introduced which would be obligatory on the architects' union which at the same time has control over the previously mentioned system of accounts which lies at the bottom of the bid.

As things stand to-day the contractor is not relieved from supplementary charges if his work fulfills all calculated expectations yet is not sufficient to attain the prescribed room temperatures. There are no limits to the care necessary in building construction where loose windows and doors play a large role.

Isolated steam heating plants for separated buildings or entire districts have been built with great expense, carefully executed as to technical detail and equipment. Recently, however, such plants have been arranged with hot water under pressure from pumps. Water under pressure has the advantage of overcoming

differences in surface levels in building localities better than steam which needs to rise.

Opposed to the style of long distance heating with water, the proposition has recently gained favor whether it is not more economical to specify that the heat be transmitted in gas form, or in exceptional cases as electricity and there transformed into heat where it is needed. By this means the loss of heat, which is unavoidable in long distance heating, is done away with—a loss which is more sensitive depending on the location of the demand for heat as opposed to the capacity for which the distributing pipes are calculated. Added to this is the loss which arises from the necessary accumulation of heat at the central plant, as opposed to the possible escape of gas at a reservoir which is small.

The foregoing is supported by the utilization of manufactured or "industrial" gas, formed as a by-product in coke production which is now collected and distributed over wide stretches of territory at a low price. Efficient heat production for hot water or steam heating with gas firing will probably be a new project in Germany in the near future.

In the realm of industrial heating plants for factories and the like, the application in Germany of blast heating increases, known for some time as Sturtevant heating. From this there develops simultaneously active inquiry for suitable blowers or ventilators with high efficiency. A committee of the Society of German Engineers last year, after years of labor, established rules for ventilators which are published in the journal of that Society, Vol. 56, No. 44.

As a heating medium for blast heating the waste heat from gas and oil motors (Diesel) is being used, often also the water heat of these motors is used. A large plant for the principai work shop of a railroad requiring 3,394,000 units of heat exists where, as a heating medium for the coils of pipes of the blast heating, the heat of combustion of the generator gas is used directly. Of similar increasing interest there are found blasts for ventilating plants in spaciously designed buildings for schools, theatres, convention halls and athletic meets. The desire for a large velocity of air in a distributing system for ventilation increases and correspondingly the demand grows that these air currents be conducted into the rooms free of draft. For cleaning the air in Germany, filters made of fabric are still preferred though air washers would be more suitable.

Construction and operation of blowers and their accessories for mechanical ventilating plants in factories, etc., find attentive consideration. The increasing cost of fuel compels one to bring to the highest possible development and utilization the attainable heat contained in the fuel, but also to make the most sparing use of the heat developed. For these automatic regulators are introduced by means of which either the developed heat is apportioned out only to the extent which corresponds to the definite object, or the temperatures remain automatically at an established height in the warmed space. So far as heating dwellings is considered, the demand for an automatic heat regulator is furthered by the fundamental laws of health instruction. The Johnson apparatus for temperature control has been introduced. Reliable automatic regulators and all arrangements for isolated installation of regulators find a good market.

In closing it should be remarked that the autogenous welding system is being increasingly introduced and proving its value as time saving and advantageous for repairing containers and for joining pipes in the installation of heating and ventilating plants.

CCCXLI

REPORT OF COMMITTEE APPOINTED TO CONSIDER UNIFORM METHOD FOR TESTING HOUSE HEATING BOILERS

In submitting the following report your committee realizes that there are opportunities for differences in individual opinion. It is the hope that the members of the Society will offer helpful criticism and suggestion in writing to the end that a code for testing boilers will be evolved to meet general conditions. In this way your committee will obtain the most help, as we believe more good can be accomplished from the consideration of written suggestions than can be obtained by general discussion at this time.

In taking up the work consideration was given to all matter which had been previously presented on the subject, but it was found that very little time or thought had been given to the question of boiler tests whereas a great deal of time had been given to the question of boiler ratings, although it has been generally recognized that some general standard for testing boilers should be adopted before any consideration could be given to the question of boiler ratings.

Communications were addressed to various colleges and manufacturers with a view of getting such information as was available from those sources, but it would seem from the replies received that very few of the colleges, if any, had established testing stations and but few of the boiler manufacturers. Some manufacturers were very willing to give such information as they had in their possession, while others had some hesitation in offering any information.

If your committee understands the work laid out for it correctly it would appear that its recommendations should solely apply to a condition for test which has to do with the operation of a specific boiler under conditions approaching as nearly as possible those under which the boiler is to be installed. Therefore, the testing of the boiler for such results becomes a comparatively simple operation compared

with the generally accepted theory of boiler test that all relations of one part of the boiler to another should be taken into account, that is, ratio of heating surface to grate surface, proportion of direct surface to indirect surface, etc., etc.

While it is of course possible in testing a boiler to take readings which will allow consideration of varying features of design, it is not intended that this report should deal with such refinement of laboratory tests as apply to design or to set forth a rigid form of test to be applied in all instances without variation. This report, therefore, will have to do with only those items which are essential in the proper rating of the boiler for commercial or sales purposes.

It is recognized that conditions in individual testing stations may be such as to be more practical with one form of apparatus than with another, but it is our hope that we can submit a general plan which will cover the correct principles and will serve the needs in a practical way. We shall therefore confine our remarks to a code for testing boilers which will have for a specific object the determination of the amount of steam which a boiler will furnish when burning a definite quantity of coal per hour for a given number of hours without attention to the fire, and under a fixed condition of draft tension. In other words, this code will cover what we believe to be performance conditions.

It should be borne in mind that a house-heating boiler is generally run under varying conditions. Therefore, any series of tests which are made should take this fact into account and it would seem that to obtain the proper working capacity of a boiler there should be at least three series of tests made on each. First, one series under maximum draft conditions burning the fuel out in as short a time as possible. Second, one so run as to burn out the fuel in a definite or fixed number of hours, as nearly as possible. Third, one with drafts regulated so that slow combustion rate shall maintain, this slow rate being such as to hold the fire the longest number of hours possible and yet maintain a constant evaporation.

A sufficient number of tests should be made in each series so as to obtain repeated or confirmatory results. The average evaporation per pound of coal based on those tests the rates of which fall between 6 and 10 hr. duration would in our opinion form a fair or safe average on which to base the working power of the boiler under actual house-heating conditions.

It is of course self-evident that tests with house-heating boilers are of necessity similar in many respects to tests such as are made with power boilers, and therefore to a large extent the methods em-

ployed in testing power boilers can be applied to house-heating boilers. In house-heating boilers conditions relating to attendance, cleanliness and method of operation are of prime importance.

It has been the practice for many years for manufacturers of house-heating boilers to rate their boilers on their capacity expressed in square feet of direct radiation or its equivalent, as it is generally desired to estimate the amount of square feet in direct radiation or its equivalent that can be supplied continuously with steam without attention to the boiler for an extended period of time. It is evident that within certain limits the amount of water evaporated per pound of coal would not vary to any considerable extent and within these limits a definite amount of fuel consumed in a short period of time would serve more condensing surface than if the same amount of fuel were burned during a long period of time.

It has seemed to the committee that in order to have a uniformity in the matter of codes, so far as possible, it would be wise to adopt the general scheme and arrangement as indicated by the American Society of Mechanical Engineers, and, therefore, reference will be made to the code of that society where our suggestions for code precisely agree with the code of that society.

APPARATUS AND INSTRUMENTS

The apparatus and instruments used in testing should include the following: Feed water tanks calibrated or to be used in connection with weighing scales; air pump, if water is to be fed by compressed air; weighing scales for weighing fuel, ashes, etc.

Differential (Ellison) draft gauges, at least three in number for measuring draft tension, in ashpit, over the fire and in the smoke pipe;

Accurately calibrated thermometers for measuring temperature of escaping gases, feed water, and temperature of steam;

Steam separator for attachment to steam pipe, separator to be thoroughly covered with non-conducting material;

Blanket covering consisting of one-ply 2-lb. asbestos paper and 1-in. hair felt which would make a desirable covering for the boiler.

Gas analysis apparatus for determining composition of the flue gases (Orsat);

Log sheets on which to keep accurate record of various readings.

The use of the various instruments is very well set forth in the report of the Power Test Committee of the A.S.M.E. and it would seem needless to repeat same in this report.

RULES FOR CONDUCTING EVAPORATIVE TESTS

Inasmuch as the object of the test is to ascertain the amount of water evaporated per pound of coal fired, all measurements and readings should be taken in such way as to give this result.

The boiler should be set up connected to a suitable chimney flue.

The boiler should be thoroughly boiled out with a solution of sal soda, potassium hydrate, or sodium hydrate and then thoroughly rinsed with clean water to remove any foreign matter.

The piping should be connected in such a way that the steam may be carried to a point away from the boiler and piping arranged so that its condensation may not flow back to the boiler itself.

The separator should be attached to the flow pipe and from the bottom of the separator a pipe should be connected in such a way as to form a water seal and with an open end so that surplus water may be conducted into a pail or barrel for weighing at completion of test.

The piping should connect the calibrated water feeding tanks into the return of the boiler, with all necessary valves and connections, thermometer cups, etc. The water should be fed to the boiler continuously from calibrated tanks, thus showing every pound of water that enters the boiler.

Special care should be used in all readings.

Where weighing tanks are used or water is fed by gravity extra precautions should be taken to avoid error in readings.

Three draft gauges suggested as part of the equipment, should be used to determine pressure loss in the ashpit, pressure loss through the fuel, and pressure loss through the flues of the boiler.

The steam pipe from the boiler should be left open to the atmosphere so that the test can be carried on at atmospheric pressure, as we believe that running a boiler under pressure gives no more accurate results as regards capacity and efficiency than may be obtained by evaporating the water at atmospheric pressure.

FUEL

In order that proper comparison may be made between tests, it is recommended that anthracite coal, stove-sized, such as Lehigh Valley, be used. In this connection attention is directed to statements covered by the Power Test Committee of the A.S.M.E.

STARTING

It is recommended that a preliminary fire be made and the boiler run until such time as water in the boiler steams when the preliminary fire will be dumped, the ashpit thoroughly cleaned, and a fresh

quantity of wood placed on the grate and kindled. The test shall be considered as starting at the time of firing this second charge of wood. On this charge of wood shall be placed the coal, which, for measure of comparison, should be stove-sized anthracite. The wood shall be considered as having a heating value equal to 40 per cent. of that of an equal weight of coal.

The weight and temperature of the water in the boiler at the start should be recorded.

Against the boiler should be charged all of the fuel, including the last charge of wood, and at the end of the test the boiler is to be given credit for the unburned fuel and the quantity of water fed to the boiler during the test, less any water thrown out in excess or a quantity represented by the condensation of the pipe and separator.

If water is not brought to the steaming point at the beginning of the test, credit is to be given to the boiler for the heat expended in heating the water contents of the boiler from the initial temperature to the boiling point at the atmospheric pressure at the time of the test.

It is the opinion of the committee that the "running start" in use at many boiler testing plants is not practical in connection with the testing of house-heating boilers. The amount of fuel used in a test of a house-heating boiler is so small compared with the amount used in a power boiler that any slight error in calculating or estimating the condition of the fire at the end as compared with that at the start would lead to a large degree of error in the actual calculation of the results, for it will be conceded that in small house-heating boilers in burning from 10 to 50 lb. of coal an hour, 2 or 3 lb. of fuel would make quite a difference in the results, while it would be almost impossible for the eye to determine such a small difference. Further than this it would prevent tests from repeating, that is, in running a series of tests a sufficient number should be made so as to get confirmatory results or until the results repeat very closely.

It is of course to be expected that no two tests will be exactly alike, but within certain limits tests should be conducted until they confirm one another. If there is a great difference between tests it is undoubtedly a sign that either false readings have been made, chimney conditions are not right, or that mistake has been made in calculation.

Readings should be taken at not to exceed 30-min. intervals, while draft and stack temperatures should be taken at 15-min. intervals.

Gas analysis should be made at least every hour to get fair average results.

STOPPING

When the time set for the end of the test arrives the fire should be dumped or combustion stopped by some other method such as spraying the fire with water. The contents of the firepot when dumped should be placed in tightly covered cans where they may be left to cool.

After cooling, the unburned coal and ash should be separated, the unburned coal weighed and deducted from the total quantity of fuel fed to the boiler. A proximate analysis of the coal should be made in order to determine its various constituents.

The subjects, "records," "sampling and drying coal," "ashes and refuse," "calorific test and analysis of coal," "analysis of flue gases," "smoke observations," "calculation of results," are all covered so clearly in the report of the Power Test Committee of the A.S.M.E. that we would refer to them without extending this report to quote them verbatim.

While it is not within the definite instructions of this committee to suggest a method for determining ratings, yet it would seem only logical that there should be suggested a formula which shall include the elements or factors which go to make up the commercial rating, and we therefore suggest the acceptance of the following equation—

First, where the boiler is to be used for house-heating work and is expected to maintain its capacity for a number of hours without attention—

$$\frac{C \times 0.8 \times E}{T \times 0.25} = R$$

Wherein C expresses the fuel carrying capacity of the boiler; E, the average evaporation per pound of coal based on those tests in which the duration rates fall between 6 and 10 hr.; T, the time boiler is expected to operate without attention; R, the rating in square feet of direct radiation or its equivalent (load on boiler); 0.8, the portion of the fuel which shall be considered as available for the time T; in other words, it shall be considered that 20 per cent. of the full fuel holding capacity will be a reserve on a rekindling charge unless otherwise stated by manufacturers. The term 0.25 shown in the denominator, shall be considered as the amount of steam condensed per square foot of steam radiation per hour when standing in air at 70 deg. and with a temperature equivalent to 2 lb. gauge pressure at the boiler (sea level).

Where boilers are installed under the care of a fireman and under constant attendance, C in the foregoing formula may be considered

as the amount of coal burned per hour—the 0.8 factor and factor T may be omitted, making the formula read—

$$\frac{C \times E}{0.25} = R$$

C in this case represents, as stated in the foregoing, coal per hour.

E. A. May, *Chairman* F. L. Busey
A. C. Edgar A. G. Cripps
Ralph Collamore

DISCUSSION

A Member: One point I would like to make in connection with this report, which I have also mentioned to Mr. May. I cannot reconcile the fact that these tests are to be run under a fixed condition of draft and also at a certain rate of combustion. It seems to me that one of these tests is entirely dependent upon the other. They state in their report that the rates of combustion should be free—fuel charge should be burned up in six to ten hours, and also that the tests should be run under fixed conditions of draft attention. I have made a good many of these tests and I find that when you change one condition the other is affected. Those two conditions are entirely dependent upon each other. It seems to me that while the measures of draft attention are very interesting as matters of record, what you are really after is to establish the rate of combustion and you can get just as accurate, just as dependable and just as valuable results without mentioning the draft attention at all. You can get all the practical information you want to get by taking the draft tests.

Professor Kent: Mr. President, I cordially agree with what the last speaker has said. I suggest that before presenting the final report they have a series of tests made and I think they will have considerable difficulty in carrying out their conclusions.

Mr. Mackay: Under natural conditions of house heating boilers, where they run for a long time without attention, say eight hours, I have found the best results were obtained by using a free burning coal, such as Lackawanna, while here we state Lehigh Valley, which is a harder coal and under conditions of

draft which might be obtained in a laboratory and perhaps not in the average house heating apparatus, my opinion is that we would be deceiving ourselves by making a short test on a strong draft of a hard quality of anthracite coal. In power boilers, such as the tests reported here, with firemen and a strong draft, they can use with good results the coal specified, but in my practice I recommend for fuel—that they use free burning anthracite coal, not a very hard coal that requires a strong draft to burn it. I think that the committee should take that into consideration in deciding that a boiler should be run six to ten hours without firing.

Mr. Newport: The report says "approximate analysis of the coal should be made in order to determine its various constituents." I believe that an analysis of the unburned fuel should also be made because that varies considerably from the fuel as fired. It does not show an exact result.

Mr. Gombers: You will recall that your Society and the American Society of Mechanical Engineers have been more or less in touch in the past to arrive at a basis of rating boilers by manufacturers. They all have different ideas. We sent a communication to your Society through Mr. Scott, calling your attention to the report of our Committee on Standardization, made at our last convention in Niagara Falls, and if you will bear with me I will read one paragraph, it is as follows:

"First: That it shall not be necessary to fire the boiler more often than once in eight hours to carry its rated load continuously.

"Second: That coal used shall contain not less than 12,000 B.t.u. per pound of coal as fired.

"Third: That boiler ratings shall be based on a condensation of .30 of a pound of steam per hour per square foot of direct cast iron radiating surface.

"Fourth: That the area of the vertical smoke flue and its height shall be great enough to provide a sufficient draft.

"We believe that if the makers will publish such tables as they will guarantee and back up, that we are putting the responsibility for the rating of the boilers directly on the manufacturers, where it belongs."

In other words, make it possible for the ordinary steam heating contractor throughout the country to pick up a catalogue and find there the rating of a boiler that he could use and say

it would do a certain amount of work if fired for eight hours. For some years our Association has been working along those lines. If your committee on this question would be kind enough to communicate with us we would be very glad to co-operate with them.

Mr. Chew: The committee says, "In taking up the work consideration was given to all matters which had been previously presented on the subject." That covers the one point. It devotes itself to a code directly and specifically and after it has got all through its suggestions, it gives a portion of a page in its report to a suggested method of getting at a rating under the method they suggest. So I think what we have here is a code and it is a code to be tested out and wherever a man wants a rating and he is not satisfied with the rating given him he can use this method and we hope some day that the code will have a sufficient standing that it will accomplish a result.

Mr. Donnelly: I think the most valuable thing about the rating to prove the code, and perhaps the use of the rating, and the use of the code, might be more quickly and better promoted by the incorporation of this into a standard specification for house heating boilers. If the architects, the master steam fitters and the engineers could get together and agree on a standard specification for a house heating boiler, say what the boiler should be on the line of the specification, say of a horizontal tubular boiler such as the Hartford steam boiler and specify them capable of standing certain tests as to strength, capable of being cleaned, having a grate handling the fuel properly, being passed by the Boiler Inspection Department if necessary, and lastly, capable of being tested by this code and receiving its rating. That specification might specify a boiler without mentioning the name of any. It might specify a boiler having a certain rating under this code, and it seems that a standard specification of a cast iron boiler would at once combine all these things, bring them together, focused, so that if that specification came to be used at all, it would be absolutely necessary for boiler manufacturers, for contractors submitting figures under such a specification, to bring their boilers under agreement with the code and the rating.

I would like to make a motion that we appoint a committee of five to co-operate with the master steamfitters, with the architects and with engineers in general to formulate a standard specification for cast-iron house heating boiler.

Mr. Davis: I infer from this report that the intention of the Committee is to formulate a code to test a boiler where there is a question of rating. At the present time there is no standard method of testing a boiler. Now, I infer from this committee's report that this is to be a standard method of testing a boiler where there is a question. I think it is meritorious. Something of that sort ought to be done. Mr. Donnelly's idea is all right as to a specification, but I think that a standard code to be known as the American Society of Heating and Ventilating Engineers' Code for Testing House Heating Boilers is of sufficient importance to be separated from the specification. A specification could include a clause that in case of a test the American Society of Heating and Ventilating Engineers code shall govern the test.

There is one point that seems not particularly clear to me—the question of burning so many pounds per hour under certain draft conditions, I do not think goes far enough. We know under certain draft conditions you can burn 10 pounds of coal per hour per square foot of grate with a probable thermal efficiency of 40 or 50 per cent., you can burn your charge of coal in so many hours, but the draft has a great effect on the efficiency.

Mr. Barron: I suppose it has the approval of every member who has not given it much thought. You see my point of view on this boiler question—testing house heating boilers—is in conformity with cast iron boiler work that we have done. We have with us this afternoon our friend Mr. Seward. I would like to hear his opinion on this report which has been submitted. I would like to put some boilermaker on record.

Chairman Hale: We have a great deal to discuss this afternoon and a number of points to take up, but I believe it would be advantageous to hear from Mr. Seward if he is willing to make a remark or two. It is not compulsory.

Mr. Seward: I did not have an opportunity to see or read this report before coming to the meeting but from listening to Mr. Chew and following his reading, I can see no objections and it looks to me like a very good report.

Of course, in considering a matter of this kind, it is necessary to determine the angle from which you are going to approach the subject. The demand for house heating boilers is possibly not always accompanied by a desire for true operating efficiency, because if such was the case, the boiler manufacturers might be

building radically different boilers than they are to-day. I am of the opinion that the demand is almost entirely along commercial lines and in a great many cases the desire for high capacity in the individual boiler is much more insistent than the demand for operating efficiency. This is an entirely commercial and natural desire and in consequence, manufacturers of boilers build them high in capacity and if possible, low in cost of production. They could build boilers high in efficiency and more expensive in construction if the demand ran that way. It is a fact, however, whether fortunate or unfortunate, I do not know which, that house heating boilers are frequently sold by their capacity and without much regard to their efficiency. Therefore, it is very natural that a boiler manufacturer should have at least one boiler on his list that is high in capacity without regard to efficiency, low in cost of production, and apparently low in price at which it will sell, based on capacity only.

A great many steamfitters—I won't say heating engineers—just steamfitters, seem to prefer that kind of boiler and as long as such is the case, there will always be manufacturers of boilers to supply their wants. I think this test code is the result of a desire upon the part of the steamfitter for some method of harmonizing the relations between boilers of different makes and design, so far as their rated capacity and price are concerned. Furthermore, I think that is the only reason existing for a test code of this kind, or probably for anything on the subject of boiler ratings. If engineers really desire anything at all, it is a uniform method for rating boilers and it is a good thing to keep in mind the difference between a method for rating and the rating itself. A few steamfitters are interested in boiler tests, but they would also like to have a uniform method for rating whereby they could determine the relative capacity of various competitive boilers. The method of rating the boiler, will of course, also determine its relative efficiency and if the method is uniform, the comparative results will be established. There is nothing, however, in the proposed test code to accomplish anything of this kind. It simply outlines a method of testing boilers which is very good, entirely practicable, very simple and will give all the results desired, providing you keep in mind that the information really needed about a house heating boiler at this time, is not its efficiency so much as its relative capacity.

We desire knowledge as to how many feet of radiation a particular boiler is capable of supplying under certain defined con-

ditions. This test code would give you all that information if conditions were definite but there is a joker in it because when you get through with your test, you will be unable to determine the relative capacity of two different boilers without first making the factor "T" uniform. That is the "nigger in the woodpile." Unless factor "T" is made uniform, we can accomplish nothing and will know no more about the subject of uniformity in methods for boiler ratings than we did four or five years ago and will be no nearer its solution than we were then.

Without making factor "T" uniform, the only point we will determine is the capacity of an individual boiler under certain conditions. The capacity of the fire pot in house heating boilers for holding coal, has a great deal to do with its capacity for supplying radiation and it will be found that the boiler that holds a large amount of coal, is rather free in its flue construction and permits a rapid rate of combustion, will show a relatively high capacity when expressed in a limited number of hours during which the coal is to be burned. This is the whole thing in a nutshell.

Unless an effort is made to have factor "T" uniform and standard under certain well defined conditions, I do not see how this Society or any other party, can accomplish very much.

I used to think at one time, that there was a very keen desire on the part of our Society and others to arrive at some solution of this problem. I am inclined to think now there is no such desire. We are pretty well satisfied with things as they are and I believe that most of us think we are clever enough to get away with it.

This boiler rating problem is a very mysterious thing. It enables a good many steamfitters who know a little more than their competitors to take advantages. Therefore, I very much question if there is a large desire on the part of the trade as a whole, for any uniform method of rating boilers. The subject is too commercial.

Boilers can be built to suit almost any condition as to firing periods and price.

I think this report, so far as it goes, is a most excellent one. It covers every point at issue with the exception of that little joker "T," and it is doubtful if that was a question which the Committee were expected to contend with. Therefore, they were justified in handling it the way they did.

Personally, I think the report should go upon our records as it represents a very distinct and definite advance along the lines we have been working, and while it accomplishes nothing so far as the desires of our members and the heating trade are concerned, it nevertheless helps to establish one fact, which is that house heating boilers are made and sold more by capacity than by efficiency. So long as this condition exists, the question is bound to be commercial rather than engineering.

CCCXLII

REPORT OF COMMITTEE ON STANDARDIZATION OF THE USE OF THE PITOT TUBE

Your committee offers the following report:

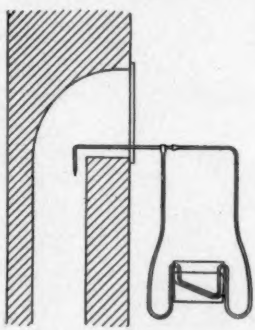
For the theory of the Pitot tube and for the derivation of formulae, reference should be made to the Journal of the American Society of Mechanical Engineers, Vol. 34, No. 9, September 1912. "Measurement of Air In Fan Work," by Chas. H. Treat; also discussions in Vol. 35, No. 2, February 1, 1913, and Vol. 35, No. 9, September 1913, "Pitot Tube for Gas Measurement," by W. C. Rowse. A report of Special Committee on standardizing of tests, Vol. 34, No. 11, November 1912, pages 1830 to 1832. Power, Vol. 37, No. 5, page 156, "Use of Pitot Tube in Air Measurement," by Frank L. Busey.

Pressure readings of 1 in. or less should be taken on an Ellison type differential draft gauge, graduated to at least hundredths of an inch, calibrated by a hook gauge. Readings over 1 in. should be taken either with an Ellison type gauge or with a U-tube graduated to at least tenths of an inch. Great care should be taken to have perfectly tight connections, especially on the static side. A slight loss of pressure here will cause a correspondingly high velocity pressure reading, and so will indicate too great a velocity.

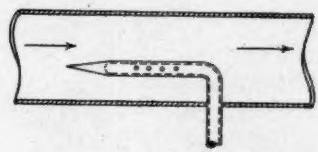
The reading should be taken at a cross section where the pipe is straight and the flow undisturbed. This should be preferably at least 10 diameters from the fan outlet, from an elbow, or from a change in cross section in the duct. This condition is difficult of attainment in many installations and where it can not be attained the average of the maximum practicable number of readings at the point farthest away from the outlet or obstruction should be taken. The readings should be taken over a plane at right angles to, and the tube should be pointed in a direction parallel to, the direction of the air flow.

Pressure readings can not be taken over the face of an outlet with a Pitot tube the same as is done with an anemometer, but by inserting the tube in the pipe at the edge of the outlet with the tip of the tube pointed against the air flow, under the same conditions as illustrated in diagram A, a traverse of the pipe can be made at a point just before it reaches the outlet.

The most difficult reading to take accurately in a current of air is the static pressure. The approved form of static tip shown by diagram B, is the form recommended for fan testing work. There should be 8 or more clean holes 0.02 in. in diameter, an equal number on each side of a ¼-in. tube 1/32 in. thick. The most approved

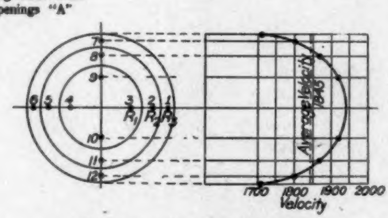


Method of using Pitot Tube at Register Openings "A"



Approved Form of Static Tip "B"

Pitot Tube "C"



Method of making Pipe Traverse "D"

STANDARD METHODS OF USING PITOT TUBE

form of Pitot tube combines the foregoing static tip with an impact tube as shown by diagram C, by means of which total, static, or velocity pressure may be read.

In making a traverse of a rectangular duct the cross sectional area may be divided into a number of smaller rectangles and a reading taken in the center of each small rectangle.

A round pipe should be divided into at least three concentric zones of equal area *per foot in diameter* and four readings taken

on a circle drawn through the center of area of each zone or ring. That is, readings should be taken across the horizontal and vertical axis of the pipe as shown on diagram D. The location of these points from the center is shown together with the accompanying table, No. 1, which gives the distance from the center of the pipe to point of reading, expressed in per cent. of the pipe diameter. To get exact results a small pipe should be divided into more zones than a pipe of larger diameter as the ratio of frictional surface to

TABLE I. PIPE TRAVERSE FOR PITOT TUBE READINGS

Distance from Center of Pipe to Point of Reading in Percent. of Pipe Diameter

No. of Equal Areas in Traverse	No. of Readings	1st R_1	2nd R_2	3rd R_3	4th R_4	5th R_5	6th R_6	7th R_7	8th R_8
3	12	20.4	35.3	45.5					
4	16	17.7	30.5	39.4	46.6				
5	20	15.5	27.2	35.3	41.7	47.4			
6	24	14.5	25.0	32.3	38.2	43.3	47.9		
7	28	13.4	23.1	29.9	35.3	40.1	44.3	48.2	
8	32	12.5	21.6	28.0	33.2	37.6	41.5	45.1	48.4

cross sectional area is greater, hence the more static pressure in proportion to the impact pressure, which correspondingly reduces the velocity pressure.

The corresponding velocities for each of these readings should be determined and an average taken of all of these velocities in order to compute the air quantity. *Inasmuch as the velocity varies as the square root of the pressure, accurate results cannot be obtained by averaging the pressure readings and taking the corresponding velocity as the average.*

The velocity may be determined from the velocity pressure by use of the formula.

$$v = 1096.5 \sqrt{\frac{P}{W}}$$

v = velocity in ft. per min.
p = pressure in in. of water.
w = weight of air in lb. per cu. ft. under the existing conditions of temperature, barometer and humidity.

With dry air at 70 deg. and 29.92 in. barometer $w = 0.0749$ whence the formula becomes

$$w = 4005 \sqrt{P}$$

With saturated air at 70 deg. and 29.92 in. barometer

$w = 0.0735$ and

$$v = 4046 \sqrt{P}$$

TABLE 2. CORRESPONDING VELOCITY FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES

Pressure		Temperatures Degrees F.									
In.	Oz.	50	60	70	80	100	150	200	300	500	550
0.1	0.0577	1242	1255	1266	1278	1300	1358	1413	1516	1704	1830
0.2	0.1154	1757	1776	1791	1808	1841	1921	2000	2145	2411	2590
0.25	0.1443	1965	1986	2003	2022	2059	2149	2235	2399	2696	2895
0.3	0.1730	2151	2175	2193	2214	2254	2352	2447	2626	2952	3175
0.4	0.2308	2485	2512	2533	2557	2603	2717	2827	3033	3409	3660
0.5	0.2884	2778	2808	2832	2859	2911	3038	3160	3391	3812	4095
0.6	0.3460	3043	3076	3102	3131	3188	3327	3462	3715	4175	4490
0.7	0.4037	3287	3323	3351	3383	3445	3595	3740	4013	4510	4850
0.75	0.4326	3402	3439	3468	3501	3565	3720	3870	4153	4668	5020
0.8	0.4614	3524	3552	3582	3616	3682	3843	3997	4290	4821	5185
0.9	0.5190	3728	3768	3800	3836	3906	4076	4241	4550	5114	5500
1.0	0.5768	3929	3971	4005	4043	4117	4296	4470	4796	5390	5795
1.25	0.7200	4393	4440	4478	4520	4602	4804	4997	5362	6027	6470
1.50	0.8650	4812	4864	4905	4952	5042	5262	5474	5874	6602	7100
1.75	1.0092	5197	5254	5298	5348	5446	5683	5912	6344	7131	7655
2.00	1.1535	5556	5616	5664	5718	5822	6076	6320	6783	7624	8195
2.25	1.2975	5892	5956	6007	6064	6174	6443	6704	7193	8085	8690
2.50	1.4418	6211	6278	6332	6392	6508	6792	7066	7582	8523	9150
2.75	1.5860	6514	6585	6641	6704	6827	7124	7412	7952	8938	9600
3.00	1.7300	6807	6879	6937	7003	7130	7440	7742	8307	9336	10000
4.00	2.3070	7857	7942	8010	8086	8233	8592	8940	9581	10780	11580
5.00	2.8840	8772	8867	8943	9027	9192	9593	9980	10710	12037	12900
6.00	3.4600	9623	9728	9810	9903	10083	10523	10950	11750	13203	14180

Where approximate results only are desired.

For circular pipe, multiply the velocity pressure taken at the center of the pipe by 0.81 or the velocity by 0.91.

For rectangular pipe, no definite factor can be given which is even approximately correct that will cover the varying proportions of width to height of the cross sectional area of rectangular ducts.

Table 2 gives corresponding velocities for various velocity pressures of dry air.

Your committee recommends the Pitot tube as a simple and convenient instrument for the measurement of air or gases, which, when used with the proper care and accuracy of reading, gives results with an error of less than 1½ per cent. with velocity pressures ranging from 0.1 in. upwards.

Respectfully submitted,

J. I. Lyle, Chairman

DISCUSSION

Mr. Lyle: I would like to see considerable discussion especially of the last page. There has been considerable difference of opinion among engineers who have used the Pitot tube regarding these factors for procuring approximate results with a circular pipe taking simply one reading and calculating from that one reading. Another question that we find engineers who have been quite familiar with the Pitot tube, who use it a great deal, raise, is the question of its accuracy within a range of 1½ per cent., especially on low velocities; at high velocities the results ought to be somewhat better. I hope we will have a complete discussion of those here who are familiar with the Pitot tube on this point.

Dr. Hill: It appears to me that this should be placed in the hands of the members of this Society to clear up this interesting proposition. We have had a great deal of difficulty in getting our Pitot tubes to record anything near alike. I think a great many engineers are in the same boat. I can never feel safe when they are making readings with Pitot tubes.

Mr. Busey: I think that is covered in the paragraph before table 1, which Mr. Lyle skipped. It gives there that reference to the figure where the different readings are to be taken, and that table gives the location in per cents. of the pipe diameter where the readings should be taken—that is, with a certain number of

equal areas in each pipe given in the first column, and the number of readings to be taken in the columns following that give the point where they should be located. A little inspection of that table will show the application of it. There is one sentence right above that table, to get exact results the pipe should be divided into more zones than pipe of large diameters, twelve-inch pipe would be divided into 12 zones and 24-inch pipe into six zones, but the relative area of those zones should be relatively smaller in the smaller pipe than in the larger one. There is another point I want to mention in regard to approximate results only being required. In engineering work it is sometimes found necessary or advisable to take but one reading but in my own work I do not do that; I always try to get it as shown on the sketch; then we are more reasonably sure of our results.

Mr. Verner: There are being conducted at the University of Michigan tests as to the flow of air in straight ducts in order to determine the variation in the coefficient due to friction. I hope that Professor Allen or some of the other men who are interested in the tests will present a paper in the near future.

CCCXLIII

REPORT OF COMMITTEE ON TESTS OF HEATING COILS UNDER FAN BLAST CONDITIONS AS CONDUCTED AT INSTITUTE OF THERMAL RESEARCH, BUFFALO, N. Y., JULY 18, 1913.

The members and guests of the American Society of Heating and Ventilating Engineers, assembled in Buffalo on July 17, 18 and 19 at the time of the 1913 summer meeting, visited the Institute of Thermal Research on July 18 and observed there a complete testing outfit set up and in operation for the purpose of testing pipe coils under fan blast conditions to determine their heat transmitting power. The pipe coils were approximately 6 feet wide and 6 feet high and the pipes were spaced on 2¾-in. centers. There were five 4-row sections of these coils set up in the heating chamber at the time these observations were made. The passage of the fresh air to the face of the coils was unobstructed, the fresh air chamber being 6 feet wide and 6 feet high. The air was drawn through the coils by a fan located about 18 feet away from the coils. The sheet metal connection from the face of the coils on the fan side tapered down in a 7-ft. length to a diameter of 36 inches. This 36-in. pipe was 7 feet long and connected with the conical piece attached to the fan inlet.

The Pitot tube readings were taken over a cross section of this 36-in. pipe near the fan inlet and four calibrated thermometers measured the final temperature of the air at approximately this same cross section. The Pitot tube was of the American Blower Co. type and was connected with its standard manometer or U tube which was set in an inclined position to make the velocity pressure readings 10 times or 20 times as great as would be the vertical reading. A red oil having a specific gravity of 0.833 was used in this U tube. These velocity pressure read-

ings were taken at 10 points each on 1 horizontal, 1 vertical and 2 diagonal diameters of the 36-in. pipe at the same cross section. These points on these diameters represented the centers of area of concentric zones of equal area. The horizontal and vertical readings were taken twice in an hour and the readings on the diagonal diameters were also taken twice in an hour. The set of readings taken on the diagonal diameters followed in each case 15 minutes later than the readings taken on the horizontal and vertical diameters.

The tests in each case were of one hour duration. The entering air temperature was taken on both sides of the fresh-air inlet connection, about 2 feet away from the face of the coils. These fresh-air thermometers were protected from radiant heat from the coils. The final temperature thermometers were located at a sufficient distance from the coils so that they were not affected by radiant heat. Steam was supplied to the coils at about 5 lb. pressure per square inch and the steam temperature observed as well as the temperature at the return pipe from each coil. The return header was dry but there was a mercury well and thermometer inserted in the wet-return line leaving the coils. This wet-return showed only from 1 to 3 degrees lower temperature than the temperature of steam in the header supplying the coils. The condensation was maintained by an equalizing tank at a definite height during the test so as to keep the steam from blowing through into the return outlet running to the weighing barrels. By this equalizing tank, which was provided with a gauge glass and steam jacket, it was possible to start the test at a certain height of condensation in the tank, practically maintain this height during the test and stop the test at the end of an hour at this same height. The condensation was cooled by means of a loop in the return pipe, which loop was surrounded with cold running water. The condensation was accurately weighed in barrels.

Steam was generated in two cast-iron boilers at a pressure ranging from 9 to 18 lbs. gauge. These pressures were reduced at the coils to approximately 5 lbs. per square inch and the exact temperature of steam entering the coils was taken for each test. There was a steam separator on the high pressure line and another steam separator on the low pressure header so that approximately dry steam was supplied to the coils. Before starting a test the coils were found to be hot all over.

An Ellison draft gauge was used to measure the loss in pressure due to the friction of the air passing through the coils. The two ends of the draft gauge were connected to static pressure tubes, one of which was located on the fresh-air side of the coils, in the center and about 1 foot away from the face of the coils. The other static pressure tube was similarly located on the hot-air side of the coils. These static pressure tubes were so constructed that the pressure had to find its way edgewise through three thicknesses of wire gauze so that the static pressure readings could not possibly be affected by any air velocity movement.

The fan was of the Conoidal type and was driven by a variable speed alternating current motor. The discharge piping from the fan outlet was provided with dampers, which, when adjusted in connection with a certain speed of the motor, would give any desired air volume handled by the fan and any desired velocity of air through the coils. The entire sheet metal work from the cold-air inlet to the fan was made air tight since the air was measured on the suction side of the fan. The entire heater casing was thoroughly insulated with blankets made of hair felt 2 inches thick and bound within two covers of asbestos cloth. The 36-in. diameter round pipe in which the Pitot tube measurements were taken and the sheet steel connection between the 36-in. pipe and the heater casing were similarly insulated in a most thorough manner. This insulation extended as far as the thermometers measuring the final temperature of the air. All the steam, return and bleeder headers, connections and piping at the coils were also thoroughly insulated with hair felt.

The velocities of air through the coils were derived from the Pitot tube and manometer measurements and were also calculated from the amount of condensation. The measured velocity averaged in the neighborhood of 6.65 per cent. lower than the velocity calculated from the condensation. Both of these velocity values were reduced to a standard of dry air at 70 deg. temperature and 29.92 in barometer. The velocities derived from the condensation values were used as test results, since these results give the total amount of heat taken out of the steam and therefore the maximum heating of the air.

A series of similar tests had been conducted with various velocities of air through the coils and with various numbers of sections deep in the direction of the air flow.

The temperature of the air entering and leaving the heater—under conditions of varying air velocities through the coils, varying steam temperatures and varying number of sections deep—were plotted on a universal temperature chart which shows the value of these pipe coils in heating effect under any fan blast conditions. These values are clearly set forth in the paper on this subject read at the semi-annual meeting by L. C. Soule, who shows further that it is of prime importance to consider the friction of the air passing through the coils along with the temperature raise desired. The velocity of the air through the coils is of secondary importance because in various makes of coils, the friction varies greatly even when the velocity is the same and the number of sections deep is the same. The engineer should determine the maximum friction he can allow through the coils and then make his selection and arrangement of coils to suit his requirements.

Respectfully submitted,

J. M. Stannard, Chairman.
W. L. Bronaugh,
L. C. Soule.

CCCXLIV

THERMAL TESTS OF HEATING BOILERS AT THE INSTITUTE OF THERMAL RESEARCH, BUFFALO, NEW YORK.

The members and guests of the Society attending the Summer Meeting of 1913 at Buffalo, had the pleasure of a visit at the Institute of Thermal Research, and among the most interesting departments inspected was the boiler testing laboratory.

A description of this laboratory, together with the methods pursued and results obtained in making the tests, should be of interest to the members that were unable to be present.

The room is located at the rear of the building, being 25 x 62 x 17 feet high, well lighted, and of fireproof construction. There are twelve chimneys of varying sizes and heights located along each side of the room, with facilities for higher extensions when necessary.

The room is equipped with all the modern appliances for testing boilers, the arrangement of same being such that the manual labor is reduced to a minimum, recording apparatus being installed wherever practical.

METHOD OF TESTING STEAM BOILERS

See Fig. 1

The feed-water is fed into the boiler by means of compressed air in a tank above the supply tank, this supply tank having a glass gauge extending from top to bottom of the tank. Alongside of the glass gauge is a scale representing pounds of water. By this means it is possible to tell at any period the rate of evaporation of the water in the boiler.

The method of feeding the water to the boiler is as follows:—Cold water from the city mains is allowed to flow into the supply tank until it has filled and as this water is under city water

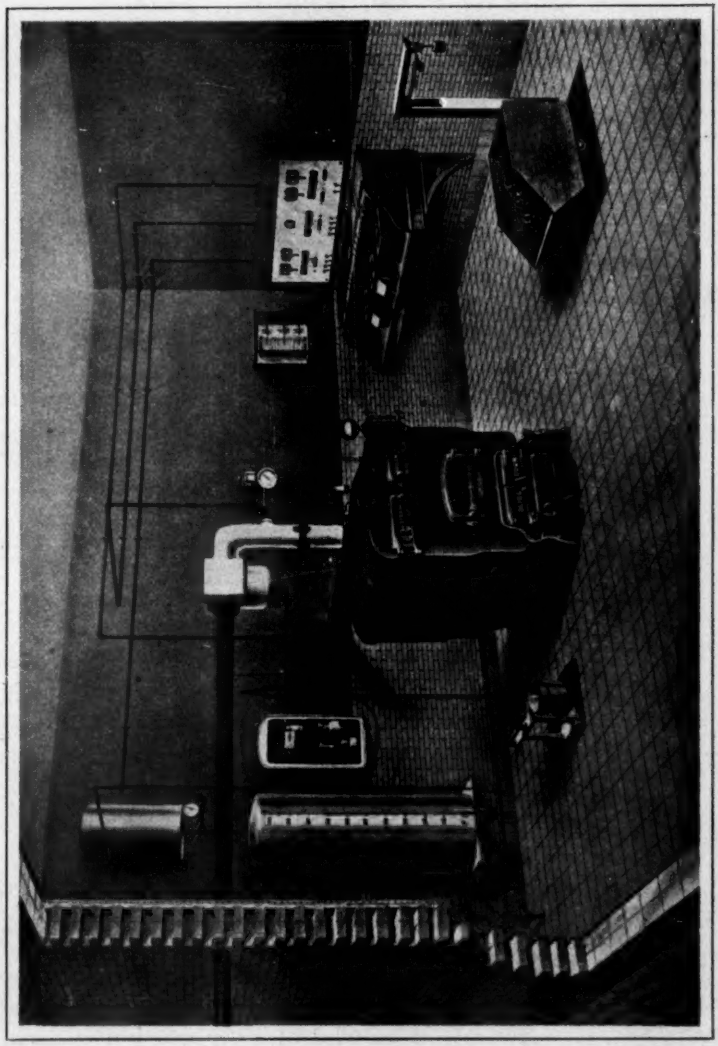


Fig. 1

pressure it forces the air up into the air tank, a pressure gauge on the air tank indicating the amount of air pressure thus formed. The city main cocks are then closed and the boiler feed cocks opened sufficiently to maintain a constant water line in the boiler to compensate for the loss of evaporation in the boiler under test. The rate of evaporation is hand controlled with the draft damper, check draft damper, etc., this rate being determined before starting the test.

The temperature of the feed water is continuously taken with an electrical thermometer inserted in the feed pipe near the supply tank, and is automatically recorded in ink upon the paper chart in the recording instrument.

The temperature of the steam leaving the boiler is taken continuously and automatically by an electrical thermometer inserted in the flow pipe just above the top of the boiler, a constant running record of the temperature of the steam being recorded on the chart of the recording instrument.

The temperature of the flue gases is taken by means of an electrical recording pyrometer, and the flue gases are analyzed by a CO_2 recorder. This instrument automatically and continuously draws in samples of the flue gases from the products of combustion, recording on a paper chart in the instrument the fluctuating percentages of carbon dioxide.

The chimney draft in inches of water is automatically recorded on the paper chart of the recording draft gauge, while the temperature, pressure and humidity of the surrounding air is taken by a recording thermometer, barometer and hydrometer. The variations of atmospheric conditions may not be material, but as these variations affect the combustion of fuel, these observations are of value for deductions.

All steam boiler tests are made at atmospheric pressure, the steam supply from the boiler being extended through an opening in the wall to the atmosphere. In order to avoid the possibility of water going out with the steam and being counted as water evaporated, a steam separator is inserted in the steam supply, the drip from the steam separator being provided with an open trap discharging into a pail. All of the water from this separator is weighed and charged back against the amount of water evaporated during the test. The steam supply and separator as well as the boiler is protected with an non-conducting covering so that the loss due to radiation from the pipes, boiler, etc., will be reduced to a minimum.

The calorific value of the fuel to be burned during a test is determined by the Emerson calorimetric bomb (see Fig. 2) and checked by the same sample being subjected to an ultimate analysis by a chemist in the Chemical Department of the Laboratory, using Verband's formula.

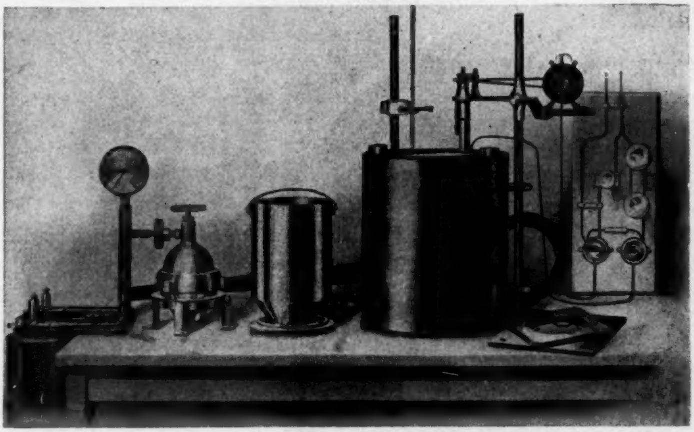


Fig. 2

In running a test the temperature of the water in the boiler is first brought to the boiling point by a wood fire, after which this fire is dumped and a sufficient amount of oil soaked wood for igniting the coal is charged and ignited. The weight of this wood is taken and is usually estimated as four-tenths of the weight of an equal volume of hard coal. Coal is then fired as rapidly as it becomes ignited until the full charge is fired, this amount being determined and weighed before starting the test.

At the end of the test the fire is dumped and partially extinguished by water from a hose, after which it is discharged through an opening with a removable lid in the floor of the ash pit, through a metal chute to which an ash can is attached located in the basement. This can is then closed with a tight fitting lid and the residue is allowed to cool. After this has cooled, the ash is separated by means of a revolving ash separator and all slate and clinker, if any, is separated by hand, leaving the unburned fuel, all of which is carefully weighed. The weight of the total residue is taken from the original fuel as fired, the remainder

representing the weight of the combustible, which, multiplied by the calorific value per pound determines the total heat generated during the run.

The actual amount of coal burned during the test is arrived at by deducting the unburned fuel from the total fuel placed in the fire pot, while the amount of fuel burned per hour is obtained by dividing the total fuel burned by the number of hours covered by the test.

The total number of pounds of water evaporated during the test is multiplied by the factor of evaporation for the average temperature of the feed water, giving the total evaporation from and at 212 degrees Fahrenheit, and this amount divided by the number of pounds of fuel burned gives the evaporative power available per pound of fuel.

The capacity of the boiler, in square feet of condensing surface based on two pounds pressure at the boiler developed during the test, is obtained by dividing the average evaporation from and at 212 degrees per hour by the factor of condensation .25.

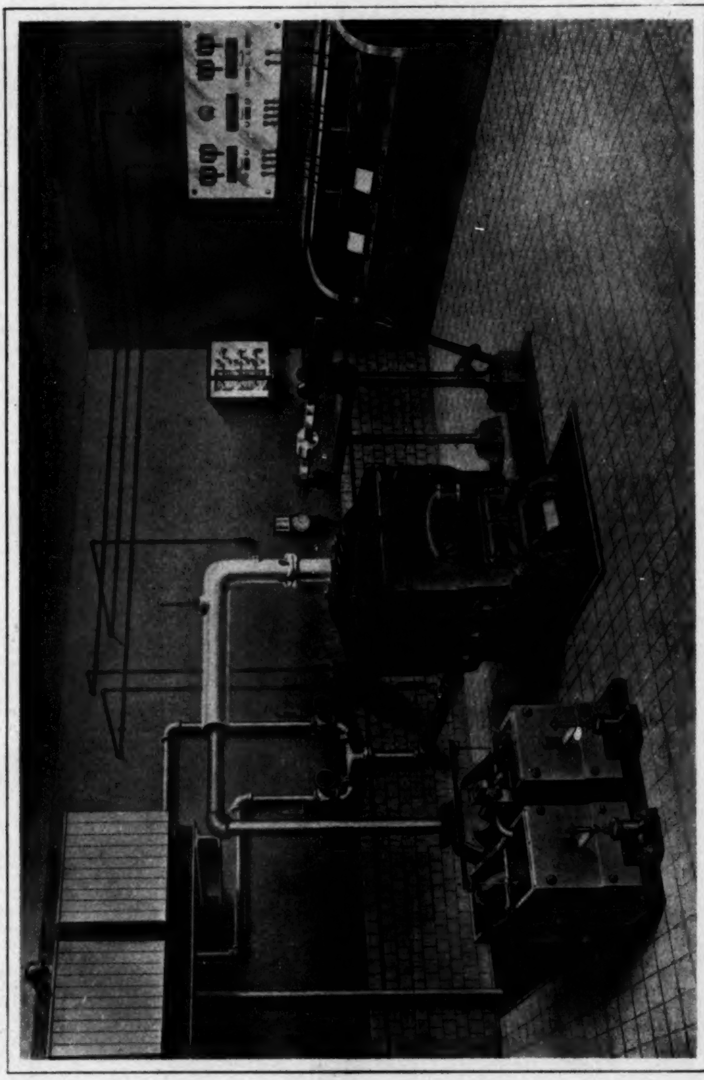
METHOD OF TESTING HOT WATER BOILERS

The process of testing the capacity and efficiency of water boilers as it applies to fuel, etc., are identical with those followed when testing steam boilers.

The return water is fed into the boiler by gravity from two tanks, located above the boiler, one supplied with hot water and one with cold, the quantity and temperature of which are controlled by valves in the pipes leading from these tanks. The temperature of the return water as fed is taken continuously by means of an automatic recording thermometer. The temperature of the flow water out of the boiler is similarly taken and recorded. (See Fig. 3).

The flow water pipe is suspended over and discharges alternately into twin weighing buckets, each bucket after receiving an exact weight or quantity of water, automatically dumps into a tank beneath the floor. In doing so it tilts a chute that is suspended on trunnions over the buckets and beneath the mouth of the flow pipe, thus diverting the flow of water into the empty bucket. This action is registered on a mechanical counting machine, recording the quantity of water that has passed through the boiler under test.

The capacity of the boiler is determined by the number of heat units that the water has absorbed in passing through the



Mechanical and Electrical Apparatus Employed in Testing Capacity of Water Boilers.

Fig. 3

boiler, reduced to an hourly basis and divided by 150, the hourly heat transmission of one square foot of average direct radiation.

Regarding the method of rating boilers, the committee is of the opinion that in rating a house heating boiler on as long a firing period as eight hours, the rating should be based on the hour showing the lowest evaporation, and not on the average for the period. In some eight hour tests the evaporation shows a difference of 100 per cent. between the high and the low hour, and of over 40 per cent. between the low hour and the average for the eight hours. This difference is probably greater when the boiler is run by an inexperienced fireman, who is usually the house holder. We also believe that boiler tests should be conducted under the same conditions of firing as occurs under which the boiler is installed,—not start from a newly kindled fire, but from a reserve charge left from a former similar firing period.

To arrive at the evaporative power per pound of fuel, the test should run through several firing periods, with the fire left in the same condition at the end of the test as it was at the beginning.

Regarding the method of arriving at the evaporative power per pound of fuel, we are of the opinion that the method used would be correct only in case the calorific value of the unburned fuel was the same as was the fuel when fired, which is rarely the case.

Respectfully submitted,

CHAS. F. NEWPORT,
E. F. CAPRON,
H. M. HART,
Committee.

TRANSACTIONS

OF THE

SEMI-ANNUAL MEETING,

July 9, 1914.

CCCXLV

SEMI-ANNUAL MEETING, 1914

First Day—Morning Session

Thursday, July 9, 1914

The meeting was called to order at ten o'clock a. m. by President Lewis, a quorum being announced present by the Secretary.

President Lewis: The President has to report that everyone in the Society did what the President asked him to do in a very friendly and efficient spirit. The effect of the President's requests will be manifest in the reports of the other officers. The President also outlined the program of entertainment for the ladies.

President Lewis then read his address which was received with applause.

President Lewis: The Secretary will now present his report.

Secretary Blackmore reads report.

Your present Secretary was appointed to and took charge of the office March 24th and since that date two ballots have gone to the members; one on April 20th regarding changes to the constitution. All the changes submitted to the members were approved excepting that one relating to balloting for new members. The form requiring the members to write yes or no after the name of a candidate on a ballot is now in force.

The following new members were elected according to the ballot sent out May 1 and opened June 1.

F. L. Austin
B. A. Broom
D. I. Cooke
J. F. Cyphers
O. H. Fogg
H. S. Haley
G. A. Henrich
J. J. Herlihy
H. C. Kimbrough
E. B. Langenberg
H. R. Linn
J. L. Moyer
J. E. MacDonald
W. Mallis
T. H. Monaghan
D. M. Myers
R. W. Noland
C. W. Petry
A. F. Knowles (Associate)
A. J. Purcell (Associate)
E. L. Barnes (Junior)
A. E. French (Junior)
F. C. Helies (Junior)
W. M. Larimer (Junior)

Advanced from Associate.

A. S. Armagnac and E. Vernon Hill.

The new Year Book has been published and mailed to the members and this book contains the Constitution as amended by the last ballot, which was opened May 20th, and by vote of the Council the changes went into effect at once. Some of the names of the newly elected members who qualified at once we were able to include in the Year Book.

While no general report can be made at the semi-annual meeting, it will undoubtedly interest you to know some comparative figures.

Cash on hand July 1, 1913	$2,101.49
Cash on hand July 1, 1914	3,216.47
Receipts to July 1, 1913	4,014.00
Expenditures July 1, 1913	3,151.00
Receipts to July 1, 1914	4,110.35
Expenditures July 1, 1914	3,617.14
Dues outstanding	1,945.00
Outstanding, fees and dues of unqualified members	60.00

You will notice the item "unpaid dues" amounting to nearly two thousand dollars, which is too large a sum to be outstanding and the members who have not paid have been urgently requested to do so.

Volume 18 of the Transactions which was paid for in April amounted to $1,510.27 while the Volume 17 which was the only one paid for in 1913, cost only $973.79.

Your Secretary attended a convention of the Society for Promotion of Engineering Education at Princeton, June 24 to 27 on the invitation of their secretary, Professor Norris of Ithaca. I was able to meet several of the professors from different engineering schools and I hope the visit will lead to a closer co-operation between our Society and the different engineering schools throughout the country.

Since January we have lost three of our members by death, namely, H. W. E. Muellenbach of Hamburg, Germany; W. A. Gates, Oklahoma City, Okla.; F. L. Busey, Buffalo, N. Y.

To the wives of each one of these, the Council, through the Secretary or President sent suitable acknowledgment.

Respectfully submitted,

J. J. Blackmore, Secretary.

President Lewis: Perhaps in just listening to the Secretary's report you have not all grasped the gist of it, which is, that our financial affairs are in excellent condition.

I feel that the Secretary should be commended on the rapidity with which he secured the printing of the papers for this meeting. He has made a special effort to have them in the hands of the members prior to the meeting.

If there is no objection, the Secretary's report will be received.

We will now hear the report of the Treasurer.

TREASURER'S REPORT

Mr. J. A. Donnelly, Treasurer, made a verbal report as follows:

There is no report due, I think, from the Treasurer. The amount of money on hand has been reported by the Secretary. In regard to dues coming in slowly, I believe that if you have good papers, and if you have a Society worth while, you will get the dues in quickly. If the organization is producing something that gives to the members more than value received for their money, the dues will come in. I belong to a number of engineering organizations. In most of them the dues come in slowly. Why? Because the men do not value their membership very highly, and do not attend many of the meetings. They neither give nor receive much of value. Let us present good papers so that our members will feel that they are losing a great deal if they give up membership in the organization, and then you will get your dues in promptly as soon as you send out your bills. If the papers are not sent out in advance of the meeting, if they are of indifferent quality and do not contain much of useful information; if your volumes of Proceedings are largely old straw thrashed over, then your dues will come in very, very slowly.

Give something to the members that is worth ten or twenty dollars, and then you will have no trouble in getting the ten dollars, and no man will want to be dropped for non-payment of dues. We want to add a little to our prestige. I am not in favor of harsh methods of forcing members to pay up. I do not believe in trying to bring undue pressure on delinquents. A man may pay his dues under such circumstances, but next year he will drop out because he doesn't like the process.

President Lewis: There is no report from the Council. As Chairman of the Council I will say that we have had several

meetings and are operating in perfect harmony. We trust by the end of the year to show some results of our efforts and to have good papers along the lines suggested by Mr. Donnelly. In connection with the lamentable death of a number of our members, I wish to read a letter I received from Mrs. Busey. We particularly feel the death of Mr. Busey, who was one of our best workers. He delivered a paper before the New York Chapter last winter which received such favorable comments that it was the wish of the Council that he be invited to present that paper at the Annual Meeting next January. He asked for time to revise the paper and to elaborate it by various cuts that he wished to show with it. The following letter was received by your President from Mrs. Busey:

"July 5, 1914.

Mr. S. R. Lewis,
Chicago, Ill.

Dear Sir:

I wish to thank you for your deep sympathy at the time of the death of my dear husband. Your Society has lost one of its most enthusiastic members. Last February Mr. Busey gave a lecture on fans before the New York Chapter of the Society, similar to the one given in Chicago in April. While in New York some of the Committee asked him to prepare a paper for the Annual Meeting along the same lines. He thought best to work on it at spare moments while the data was fresh in his mind. He finished it just before his illness. I have the paper here, together with the lantern slides. If you care to have it I will be glad to send it to you.

I trust the Society will have as pleasant and profitable a meeting as we had in Buffalo last summer.

Sincerely,
(Mrs.) Lillian M. Busey,
201 W. Green Street,
Urbana, Ill."

I think that was a very nice thing for Mrs. Busey to do. It seemed to me that it would be a rather fitting memorial to Mr. Busey to have that paper presented at the Annual Meeting, so I wrote this letter to her:

"Chicago, Ill., July 6, 1914.

Mrs. Lillian M. Busey,
201 W. Green Street, Urbana, Ill.

My dear Mrs. Busey:

This is to thank you for your letter of July 6th and to accept in behalf of the Society your kind offer of Mr. Busey's paper and slides. I think I can assure you that a special feature will be made of this paper and its presentation at the Annual Meeting in New York next January as a memorial to Mr. Busey.

I think very likely resolutions will be passed at the coming meeting, of which you will receive a copy.

Permit me to thank you for your interest and kind wishes.

Yours very truly,

S. R. Lewis."

I think no special action is required on the matter.

I believe the next thing we should consider on the program is reports of various Chapters. Have we such reports?

The Secretary read reports from the Illinois, New York and Massachusetts Chapters.

ILLINOIS CHAPTER.

The Illinois Chapter does not hold meetings between May and October.

The year 1913-1914 has been one of the most instructive and satisfactory years since the existence of the Chapter. The idea suggested by the Board of Governors of the debating the relative merits of competing methods of accomplishing certain results, was a most happy thought and stirred up quite a little interest.

It has always been the practice of this Chapter to devote at least two meetings to so-called open meetings wherein we would invite outside talent to participate and to have as our guests, those particularly interested in the topic under discussion.

At our October, 1913, meeting the following officers were elected:

President, H. M. Hart.
Vice-President, C. F. Newport.
Secretary, W. L. Bronaugh.
Treasurer, August Kehm.

The topic of the November meeting, was a debate on the relative merits of "UPWARD METHOD OF VENTILATION VS. DOWNWARD METHOD OF VENTILATION."

At the *December meeting* we considered the relative merits of "FORCED CIRCULATION OF HOT WATER VS. DIRECT STEAM VACUUM HEATING FOR INDUSTRIAL PLANTS."

The *January meeting* was assigned to the consideration of the merits of "HOT BLAST VS. DIRECT STEAM HEATING FOR FACTORY PURPOSES."

Our *February meeting* was for the purpose of receiving a report from the Chicago Ventilation Commission, the Chapter having three members on this Commission. The Chapter entertained several members of the Board of Education and the entire Ventilation Commission at dinner,—and after dinner, those present visited the Chicago Normal School for the purpose of seeing what Mr. Shepard and the Commission had been doing with their tests. It was pleasing to note that they were accomplishing considerable and getting nearer to some conclusions.

Dr. Hill demonstrated to the Chapter, the method employed by the Health Department in taking air samples and testing for proper ventilation.

The suggestions of Mr. Shepard, as to constructive details of buildings adaptable for proper ventilation for school jobs was discussed. The meeting was a most instructive one.

At our *March meeting* it was our pleasure to elect to membership:

Clinton E. Beery, Rockford, Illinois;
J. F. Tuttle, Chicago, Illinois;
Wm. H. Chenoweth, Chicago, Illinois;
C. C. Cheyney, Chicago, Illinois;

all members of the Parent Body.

The topic discussed was one particularly interesting to all members of the Chapter, which was the relative merits of "Hot Water vs. Modulated Steam for House Heating Purposes"—it being interpreted that modulated steam would also include vapor heating. This topic brought forth a more generous discussion than any topic yet presented to the Chapter. Practically every one present indulged in the discussion.

The *April meeting* was a discussion of "AIR WASHERS" and the Committee selected its particular discussion from standard methods of testing washers. This topic and the work done by

this Committee is the basis of the paper presented at this Semi-Annual meeting, by Mr. Stacey. A number of lantern slides were used in illustration.

After this topic was presented, Mr. Frank Busey of Buffalo, N. Y., gave a historical sketch of the development of the centrifugal fan, illustrating this with lantern slides.

The Chapter used the question box to a limited extent, and one of the questions asked, suggested the topic discussed at the *May meeting,*—that is, the smoke situation, and the Chapter entertained as its guests, three members of the Chicago Smoke Department. Mr. E. A. May discussed "CHIMNEY DRAFTS" for power and heating purposes, also the proper method of firing, and the allowances required by the Chicago Smoke Department, which suggested the topic of Mr. Widdicombe's paper.

The Chapter has contributed further, in a financial way, to the up-keep of the Chicago Ventilation Commission, to enable them to conduct tests, and this Commission is about ready to publish and distribute preliminary report of its conclusions.

Financially, the Chapter is in good condition, and we are anticipating another instructive year.

Respectfully submitted,

W. L. BRONAUGH, Secretary.

NEW YORK CHAPTER

As Secretary of the New York Chapter of the Society, I take pleasure in reporting upon the year's work of the Chapter as follows:

The Constitution of the Chapter was changed in a number of minor clauses, the principal one being that the annual meeting is now held in April instead of October. This makes the present year a short one—of but six months.

The monthly meetings of the Chapter have been fairly well attended, the topics discussed at the meetings being:

Vacuum vs. Vapor Heating.

Control of Atmospheric Conditions in Printing Establishments.

Fan Selection.

School House Heating and Ventilating.

As usual, a committee was appointed to take charge of the entertainment features at the annual meeting of the Society in January.

The financial condition of the Chapter is in very fair shape, the Treasurer having a good working balance to start the next year with.

The membership of the Chapter totals 72 as against last October—78. We have lost 5 members by resignation, and there have been 3 dropped for non-payment of dues. There have been 2 new members elected.

Respectfully submitted,

W. F. Goodnow, Secretary.

MASSACHUSETTS CHAPTER

OFFICERS:

President—J. W. H. Myrick, 53 Devonshire Street, Boston.

Vice-President—Charles F. Eveleth, 120 Boylston Street, Boston.

Secretary—Frank Irving Cooper, 33 Cornhill, Boston.

Treasurer—William T. Smallman, 52 Sudbury Street, Boston.

Board of Governors—Albert B. Franklin, Charles Morrison, H. W. Whitten.

The Chapter has held regular monthly meetings which have been well attended. These meetings have usually been addressed by guests notable in their several occupations.

The Chapter decided, as a body, to oppose the bills before the Massachusetts Legislature, proposing that the ventilation of school buildings be placed under the State Board of Health. President Myrick was delegated to carry out the wishes of the Chapter.

While it would seem that State Boards of Health or Education should have the control of the planning of school buildings such control has not proved satisfactory in Massachusetts under a previous administration, largely through the lack of interest manifested by the officers in control.

The bills were defeated.

The Chapter has had a marked increase in membership although its list of 1913 members was depleted through the resignation of Joseph A. Moore, George Huey and Alfred E. Kenrick. The name of David E. Boyden was dropped for non-payment of dues. All other members are in good standing and the membership stands as follows:

LIST OF MEMBERS

Frank I. Cooper,
Charles F. Eveleth,
Robert L. Folsom,
Albert B. Franklin,
William N. McKenna,
T. F. McCoy,
Francis H. Morgan,
Charles Morrison,
J. William Muldowney,
J. W. H. Myrick,
Andrew G. Paul,
S. H. Pool,
William T. Smallman,
William G. Snow,
E. R. Stone,
W. W. Underhill,
H. W. Whitten.

Frank Irving Cooper, Secretary.

President Lewis: If there is no objection the reports of the various Chapters will be received.

Secretary Blackmore stated that owing to the fact that the Chapter years begin in October and end in May, these reports are to be considered as annual reports of the Chapters and the Chapters will not report hereafter at the Annual Meeting.

President Lewis: We will now listen to the Reports of Special Committees, first being that on "Heat Transmission of Direct Radiators." Mr. J. A. Donnelly, Chairman, New York.

Mr. J. A. Donnelly: I have heard some one say that when a man starts making tests it is with the idea of proving something. If that is so then it will be hard work to have a committee, because I do not start out to try to prove anything, but simply to ascertain facts without making deductions in advance.

The title as given in the program of this paper is somewhat misleading. The tests were for the purpose of searching out some possible method of testing as between radiators and air at comparatively low differences in temperature, not merely tests on direct radiators. Owing to the nature of the tests it is also possible to get a little data on the small convertor which may give a little useful information.

(Mr. Donnelly then read his report.)

President Lewis: Mr. Donnelly's paper is before you for discussion.

The report was dicussed by Prof. Allen, Mr. Carrier, Mr. Hart, Mr. Lewis and Mr. Blackmore.

President Lewis: The next item on the program is "Reducing Fire Risk in Blower Systems Used for Heating and Ventilating," Mr. A. M. Feldman, Chairman. The Committee of the National Fire Protection Association composed partly of members of our

Society drew up the requirements which were so interesting and seemed to the Council so valuable, that we asked them to serve as a Committee of our own body in order that we might have their findings in our transactions. Mr. Blackmore will read that report.

Mr. Blackmore read the report and it was discussed by Mr. Hart, Mr. Donnelly, Mr. Lewis and Mr. Blackmore.

President Lewis: The next order of business is "Co-operation with Other Societies Readopting a Standard for Flanges," C. R. Bradbury, Chairman. Mr. Secretary, is that a long report? If not, let us have it.

The Secretary read the report, as follows:

Washington, D. C., May 7, 1914.

The American Society of Heating and Ventilating Engineers.

Gentlemen:

In accordance with the request of the President of the Society, I attended, as your representative, the conference called by the National Association of Master Steam and Hot Water Fitters held at the Raleigh Hotel, Washington, D. C., March 7, 1914, to consider the subject of the universal adoption of a standard for flanged fittings and flanges and have the honor to submit the following report:

The following societies were represented at the conference:

The American Society of Mechanical Engineers.

American Society of Heating and Ventilating Engineers.

National Association of Master Steam and Hot Water Fitters.

Committee of Manufacturers on Standardization of Fittings and Valves.

American Water Works Association.

New England Water Works Association.

Associated Factory Mutual Fire Insurance Companies.

Underwriters' Laboratories, Inc.

United States Bureau of Standards.

Supervising Architect's Office, U. S. Treasury Department.

United States War Department.

United States Navy Department and the United States Commerce Department.

Mr. Edward B. Denny, President of the National Association of Master Steam and Hot Water Fitters, called the conference to order at 10 o'clock and after the roll call, presented a brief history of the movement for the standardization of flanged fittings.

After the opening statement by Mr. Denny, Dr. S. W. Stratton, Director of the U. S. Bureau of Standards, was nominated chairman of the conference and unanimously elected.

The differences between "The 1912 U. S. Standard" adopted by the American Society of Mechanical Engineers, the National Association of Master Steam and Hot Water Fitters and the American Society of Heating and Ventilating Engineers and the "American" standard adopted by the Manufacturers Committee were taken up and fully discussed.

At the beginning of the conference an understanding was reached that any vote taken was to be considered only as an expression of opinion of those present and not binding upon the departments or associations which were represented.

Nearly all the differences in the schedules were finally adjusted by unanimous consent.

It was arranged, however, at the Washington Conference, that the committees of the American Society of the Mechanical Engineers, the National Association of Master Steam and Hot Water Fitters, and the Manufacturers Committee should meet in New York City within sixty days and settle several technical questions and put the new standard in complete form.

The Washington Conference was in session until about 5:30 p. m. with only a short intermission for luncheon.

The result of the Washington Conference of March 7th and the New York Conference of March 20th is the production of a new schedule for Standard and Extra Heavy Flanged Fittings to be effective January 1, 1915.

All questions in connection with the new standard were settled practically unanimously except the name.

The question of name for the new standard is to be decided by letter ballot and will undoubtedly be announced before the meeting of this Society.

The new 1915 Standard is practically the same as the 1914 "American" Standard except that short body patterns for both standard and extra heavy weight fittings below and including sixteen inch, have been eliminated to insure interchangeability, and the larger extra heavy fittings are to have nominal size ports instead of ports ¼-inch smaller than nominal.

I strongly recommend the adoption of the new 1915 Standard by the American Society of Heating and Ventilating Engineers.

Mr. Nelson S. Thompson, who was appointed as a representa-

tive of this Society to the conference was not able to attend on account of pressure of business, but concurs in the above recommendation relative to the adoption of the new Standard by the Society.

I am sending herewith for the files of the Society, a copy of transcript of the minutes of the Washington Conference held March 7, 1914; also letters relative to the meeting held in New York City on March 20th, 1914, from Mr. Henry C. Stott, Chairman of the Committee of the American Society of Mechanical Engineers, Mr. A. M. Houser, Chairman of the Committee of Manufacturers, and Mr. Henry B. Gombers, Secretary of the National Association of Master Steam and Hot Water Fitters.

Respectfully submitted,

C. R. Bradbury.

President Lewis: While I have not had any conference with members of the Council with reference to this report, I think it is extremely questionable whether we should adopt the recommendations at this meeting. I would like to hear from any of the members with reference to this. I suggest that we merely receive the Report of the Committee, and if there are no objections that will be the order.

There were no objections, and it was so ordered.

President Lewis: Next is report of Special Committee on "Co-operation with Educational Committee of National District Heating Association," E. F. Capron, Chairman.

The Secretary read the report, as follows:

I herewith submit a copy of the report of the Educational Committee as presented at the Sixth Annual Convention of the National District Heating Association, held at Rochester, New York, May 26th to 29th, 1914, which report should be read at the summer meeting of the American Society of Heating and Ventilating Engineers. I would suggest that the report be submitted to the publication committee for their inspection as to whether any or all of this report should be printed and embodied in the minutes of our meeting.

This committee should be dismissed at this time and reappointed if a like committee is appointed from the National District Heating Association.

E. F. Capron.

Secretary Blackmore: The report is published by the National District Heating Association in pamphlet form. The Secretary will read it if it is your pleasure.

President Lewis: If there is no objection, the Report will be submitted to the Educational Committee of the Council, and if they deem best, it will be published in our transactions without reading it.

Mr. H. M. Hart: Will we all get copies of it?

Secretary Blackmore: We could hardly ask them to send us a sufficient number of copies to supply all of our members. They did send enough for the members of the Council and the Educational Committee.

The Executive Committee by the advice of the Publication Committee decided to print in the transactions only Appendix C of the report, "Test of a Low Pressure Steam Vegetable Cooker."

President Lewis: The next in order is Report of Special Committee on "Chimneys and Their Effect on Heating and Ventilating Apparatus," Robert Widdicombe, Chairman. Have you heard from Mr. Widdicombe?

Secretary Blackmore: I have just had a letter from Mr. Widdicombe stating that he does not feel that the report has been brought up to the point where it can be presented to the Society in the way that he would like to have it presented; and he asks for more time to present it at the Annual Meeting.

President Lewis: I believe that the Committee is entitled to more time. I have consulted with them, and I believe they will have a valuable report; so, if there is no objection, this subject will be continued for presentation at the Annual Meeting.

Next in order is the Report of Special Committee on "Progress in Heating and Ventilating of Industrial Buildings," E. L. Hogan, Chairman. I have Mr. Hogan's report. He stated that we might use the report at this time if we desired, but that he would prefer if possible to give it at the Annual Meeting. Next is Report of Special Committee, "For Standardizing a Method of Testing Air Washers," A. E. Stacey, Jr., Chairman.

(Mr. Stacey read the report.)

The report was discussed by Mr. Luehrs, Mr. Tait, Mr. Braemer, Mr. Hart, Mr. Carrier, Mr. Lyle, Mr. Lewis, Mr. Weinshank, and Mr. Blackmore after which the committee was continued to make a final report at the annual meeting.

President Lewis: Unless there is objection we will now adjourn until two o'clock this afternoon when we will proceed with the Report of the Committee on "Model Compulsory Ventilation Law."

The session adjourned at 12:45 p. m.

SECOND SESSION—THURSDAY AFTERNOON, JUNE 9

Meeting was called to order at 2:15, President Lewis in the Chair.

President Lewis: There is a quorum present, and we will proceed with the report of the special committee on "Model Compulsory Ventilation Law," Prof. J. D. Hoffman, Chairman.

Prof. Hoffman: Your Committee was in almost continuous session for two days and two evenings, and submits a report which of course is a preliminary report on the subject until the January meeting next. This report fills nearly ten pages. I would like to inquire if you wish to have it read in its entirety?

President Lewis: My personal feeling is that it should be read in its entirety, in order that the fullest possible number of suggestions may be received here for the benefit of the Committee; however, if there is any dissenting opinion we will be very glad to have it read by abstract. The sense of the meeting seems to be that it should be read in full.

Professor Hoffman accordingly read the report in full.

The report was discussed by Mr. Lewis, Mr. Weinshank, Mr. Chapman, Mr. Tait, Mr. Lyle and Prof. Allen, after which it was referred back to the committee for final report at the annual meeting.

President Lewis: We had the very great pleasure and honor two years ago of electing a distinguished gentleman as President of this Society. He was not able to preside at our meetings because he was abroad.

It would give us a great deal of pleasure if Professor John R. Allen would assume the Chair and let us have the benefit of his supervision for the balance of this session.

Professor John R. Allen took the Chair, and presided for the remainder of this session.

Chairman Allen: I want to say that this strikes me like a cyclone out of a clear sky. I thought I was occupying a very inconspicuous position in the audience, and hoped to remain there. I certainly am very glad to have the opportunity of

taking up some of the duties that I was expected to take up when I was elected as President. It was a source of great regret to me in not being able to assume the office of President of this Society, but conditions made it impossible for me to do so. As a matter of fact, when I was elected President I only expected to stay in Constantinople for one year; but owing to war conditions existing there, and also to the fact that construction work is very much slower in that country than it is in this, my work did not go along as fast as I expected it would, and it was necessary for me to stay there two years instead of one. Really, I was lucky to get away in two years. Conditions there are very different from those here. When you asked for a building permit under the old law the Government reserved the right to consider it for three years before issuing the permit. Fortunately, when I got over there they had amended that law so that they only reserve to themselves the right to consider it for six months. There are a good many things of that kind that are different from conditions in our country, so that it was impossible for me to come back and assume the duties of the office.

I do not care to make a long speech, but I certainly appreciate the honor you conferred at that time in electing me President, and have always regretted that I was not able to give my personal attention to the office.

The next paper on the program is by Mr. D. I. Cooke of Chicago on "Car Ventilation."

(Mr. Cooke read his paper.)

Chairman Allen: We have another paper to be read this afternoon upon a similar subject, "Car Heating by Electricity, and Temperature Regulation in Connection Therewith," by W. S. Hammond, Jr., Chicago. As Mr. Hammond is not here, I will ask the Secretary to read that paper, and if there is no objection we will then discuss the two papers at the same time.

(Secretary Blackmore read the paper.)

After which the papers were discussed by Prof. Allen, Mr. Hart, Mr. Lewis, Mr. Tait and Mr. Cooke and a resolution was passed giving thanks to Mr. Cooke and Mr. Hammond for the papers.

Chairman Allen: The next paper on the program by Prof. E. H. Lockwood will not be presented as it has not been received, but in place of it a paper will be read by Mr. O. J. Kuenhold on "Natural Gas Heaters."

(Mr. Kuenhold then read the paper.)

Chairman Allen: If there is no objection I will ask Mr. Donnelly to present his paper now, as it has to do with gas consumption and we will have all the papers on these allied subjects discussed at one time.

(Mr. Donnelly reads paper.)

The papers were then discussed together with the topic "To what extent can we economically use manufactured gas for heating," by Mr. Donnelly, Mr. Blackmore, Mr. Hart, Mr. Lewis, Mr. G. H. Barrows and Mr. Bolton and the discussion occupied the remainder of the session.

The session adjourned at 6:15 o'clock.

Third Session—Friday Morning, July 10

The meeting was called to order at ten o'clock, President Lewis in the Chair.

President Lewis: Since we are to close this session at twelve o'clock, we will ask Mr. Pryor to proceed with his paper on "The Reduction or Elimination of Noise in Mechanical Ventilating Apparatus."

Mr. R. W. Pryor, Jr.: This paper was prepared with the idea of bringing out the views of other members as to the elimination of noise in ventilating machinery which might have come under their observation. I have given here a few of my experiences which I have had contact with. After I finish if there are any of the gentlemen who have had similar experiences, I would like to get their views and have a thorough discussion of the paper.

(Mr. Pryor reads paper.)

The paper was discussed by Mr. Hart, Mr. Lewis, Prof. Allen, Mr. Lyle, Mr. Tait and Mr. Blackmore, after which the questions raised were answered by Mr. Pryor.

President Lewis: If there is no objection we will proceed to the next item, which is a paper on "Toilet Room Ventilation" and appliances used for the purpose, by R. L. Douglass, Hyde Park, Mass. Mr. Douglass is not present, so the Secretary will read his paper.

(The Secretary reads the paper.)

It was discussed by President Lewis, Mr. Hart, Mr. Blackmore and Mr. Pryor.

President Lewis: The next paper is one by Dr. M. W. Frank-

lin, "Air Ozonation." In the absence of the author the Secretary will read it.

(The Secretary read the paper.)

It was discussed by Prof. Hoffman, Prof. Allen, President Lewis and an extract from a pamphlet by Prof. F. S. Lee was read in the proceedings.

It was voted to send to Dr. Franklin a copy of the discussions and to make his reply a part of the proceedings.

President Lewis: We will next have a paper on "The Heating Industry in Canada," by Norman A. Hill, Toronto, Ont. Hoping that the administration for next year may consider our general wish to go to Toronto for next summer's meeting, and with that end in view to encourage our interest in Canada and to recognize our friends on the other side, we have requested Mr. Hill to tell us something about Canadian conditions.

Mr. Hill read the paper and as an addenda to it Mr. Hill quoted the following statistics:

"Toronto, the fastest-growing city in Canada, population nearly doubled in six years; 1907, 272,000; 1913, 505,807; 233,207 new inhabitants in six years. In order to accommodate 35,000 new inhabitants last year the Queen City spent $27,038,624 in erecting 9,884 buildings, over 6,000 of which were houses valued at $12,181,280 (without the land). 71 new factories were erected costing $2,054,950; 47 warehouses costing $1,100,600; 60 theatres and moving picture shows costing $1,119,400; 40 new office buildings costing $1,799,925; 23 new schools costing $2,378,100, bringing the total number of educational buildings to 282; and all this in one year. Every four minutes of the business day a new inhabitant arrives in Toronto. Every three and a half minutes of a working day a real estate transaction is completed."

Mr. Hill's paper was received with applause.

The paper was discussed by Mr. J. H. Davis, President Lewis, Mr. Kimball and Mr. Weinshank.

President Lewis: Our friends in Cleveland have been showing us very bounteous hospitality. They have arranged a great many interesting entertainment features, and it is due to them that we do not delay them; therefore, I am compelled to call a halt on these discussions at this time, since the Local Committee of Entertainment have arranged for a trip to Nela Park this afternoon to visit the National Lamp Works. The Convention will now adjourn to 10 a. m. Saturday morning, July 11th.

Fourth Session—Saturday Morning, July 11

The session was called to order at ten o'clock, President Lewis in the Chair.

President Lewis: The Chair is not certain whether the effects of the banquet last night have affected his eyesight, and he is a little uncertain, but he believes that he sees fifteen members present, and will therefore announce a quorum.

We have always had more or less difficulty in sticking to the program, because we start late and finish late so that we get behind on the next session; but this administration is endeavoring to show those who do not come up on time that they miss something. So, if there is no objection, we will proceed with the program, the first paper being a "Comparison of Costs of Water Power and Steam," by Reginald P. Bolton, New York City.

Mr. Bolton then read his paper, interspersing it with some side remarks.

The paper was discussed by Prof. Allen, Mr. J. H. Davis, Mr. Hill, Mr. Bushnell, Mr. G. D. Hoffman, Mr. Hart and President Lewis.

President Lewis: The Secretary will now read his paper, "Our Society, its Aims and Opportunities."

(Mr. Blackmore reads paper.)

The paper was discussed by President Lewis, Mr. Hart, Mr. N. A. Hill, Mr. Bolton, Mr. Linn, Mr. J. H. Davis.

President Lewis: We have a communication from Mr. Speller, who is interested in threads. A movement is under foot for a change in the agreed standard in pipe threads. It seems to me wise that this be referred to the Committee on Standards; if you have no objection, it will be so referred, to co-operate with other committees of other Societies toward an eventually improved standard.

President Lewis: We will now hear the report of the Chicago Commission on Ventilation read by Mr. Hart.

(Report of Chicago Ventilation Commission was read by Mr. Hart.)

President Lewis: I criticized our friends of Cleveland when we started this meeting, because I felt that they were attempting too much in the way of entertainment. I desire to retract any possible criticism I may have offered. They did not have too much entertainment, I think their entertainment was just

right! I call for a rising vote of thanks to our Cleveland members for their hospitality.

The motion was seconded, and carried by unanimous and rising vote.

President Lewis: I thank you for your unanimous endorsement of my motion. I believe that our meeting is ended unless you desire to take up some of these Topics for Discussion that are listed on the program. If not I will entertain a motion to adjourn.

Convention adjourned at 12:15 p. m.

LIST OF ATTENDANTS AT SEMI-ANNUAL CONVENTION THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, CLEVELAND, O., JULY 9, 10 AND 11, 1914.

MEMBERS.

Allen, John R.
Armagnac, A. S.
Bacon, John H., Jr.
Blackmore, J. J.
Brooks, V. L.
Bushnell, S. Morgan
Carrier, W. H.
Chapman, Frank T.
Cheyney, C. C.
Claffey, Edward J.
Cooke, Dwight I.
Cripps, A. G.
Davis, James H.
Donnelly, James A.
Ellis, H. W.
Foote, M. L.
French, A. E.
Gardner, S. Franklin
Gifford, Robt. L.
Hale, John F.
Hart, Harry M.
Hill, Norman A.
Hoffman, George D.
Hoffman, James D.
Johnson, Carl W.
Kimball, Dwight D.
Kingsbury, Wm. M.
Lewis, Samuel R.
Linn, Homer R.
Lyle, J. Irvine
Marquam, William E.
Mayer, Robert S.
McDonald, Wm. F.
McGinness, J. E.
Newport, Chas. F.
Phegley, Frank George
Pryor, Robert W., Jr.
Schlemmer, Oliver H., Jr.
Speller, Frank N.
Valentine, F. H.
Weinshank, Theo.

GUESTS.

Charles F. Beckwith
S. C. Cutler
Douglas A. Brown
Jas. F. Firestone
J. A. Miller
V. A. Root
C. A. Olson
F. R. Quay
Daniel M. Luehrs
F. L. Prentiss
Albert W. H. Spear
O. T. Carson
J. F. McIntire
Wm. M. Foster
J. C. Hobbs
George S. Barrows
Wm. H. Price
Henry F. Vaughan
J. J. Metcalfe
C. F. Hall
H. R. Hadlow
A. P. Seltzer
Max Siziies
E. M. Ashworth
Frank Saunders
F. S. Borsum
R. J. Bissett
S. F. McDonald
E. A. Stark
O. G. Ward
J. M. Farley
W. R. Brewer
W. H. Buerser
H. C. Hewitt
R. E. Stokes
A. C. Yost

W. P. M. Roberts
W. H. Smead
Howard J. Weber
Franklin Van Winkle
E. R. Roberts
C. H. Rock
J. P. Snapp
F. H. Winslow
C. A. Anderson
E. Loughnane
C. P. Riegger
F. G. Bridges
H. G. Hart
W. R. Beckley
Will Bacon
G. A. Winkel
C. C. Johnson
A. B. Knight
H. C. Shrew
L. M. Hunter
J. J. McDonald
L. I. Garrett
C. Gottwald
H. Ray Redington
H. P. Mishler
H. P. Cahill
George W. Roberts
J. C. Miles
C. M. Miles
Frank W. Billman
Milton E. Murphy

LADIES

Mrs. John R. Allen
Mrs. Frank G. Phegley
Miss Myrtle Phegley
Mrs. Theo. Weinshank
Miss Anna Weinshank
Mrs. J. D. Hoffman
Mrs. E. M. Ashworth
Mrs. F. G. Bridges
Mrs. C. C. Johnson
Mrs. W. M. Kingsbury
Mrs. J. H. Bacon
Mrs. T. E. Loughnane
Mrs. L. M. Hunter
Mrs. C. H. Rock
Mrs. J. P. Snapp
Miss Adelaide Snapp
Miss Alice Caldwell

CCCXLVI

THE IMPORTANCE OF A PROPER PERSPECTIVE

President's Address.

S. R. LEWIS.

One of the limitations of the human mind is its normal inability to become sufficiently detached as to view things in their proper perspective. After taking the utmost care in refining some detail of a process we operate for years with combinations of such refined details in connection with the most redundant, unconsidered rules of thumb. We are prone to follow precedent or to be conventional, at the expense of progress. We fail to view a clear perspective.

The history of medicine, electricity and mechanics teems with instances in which we groped all around radical improvements, finally to stumble over them. At how many points we have failed yet to stumble no man knows. The improvements in heating and ventilating have largely been developed by the stumbling process. The most elaborate computations will be made, for instance, of heat losses, pipe sizes and radiator surfaces, affecting possibly one-third of the cost of an installation and then we find that the designer guessed at the chimney size or type or height—took an incompetent manufacturer's rating on a boiler, or rendered abortive his own detailed computations by assuming that the manufacturer's competitive guess as to the capacity and efficiency of his particular apparatus, was correct.

The men whose minds have risen above the commonplace and who have been able clearly to view the perspective are our great men to-day. They have been able to devote their efforts to *all* the weak places without useless devotion to a few futile details. The capacity for infinite care and pains, which is said to form genius, the rank and file of us can understand.

Our ideal of this society is success for all. That all may succeed it is not necessary that any shall fail. The process of devel-

oping, by careful committee work, by consultation with successful outsiders, by individual genius, such as we have in our membership, is progressing safely and sanely, and our proceedings from year to year are surely becoming more and more enriched with valuable information.

I desire to emphasize, however, the necessity of proper perspective and in doing so suggest some questions which I believe the future will prove worthy of our most earnest consideration.

Overshadowing everything else is the question of conservation of natural resources. For how much longer may we waste stored heat resources to save first cost only, of buildings? Our instinct is so to live as to make living for our descendants a better proposition. How are we intelligently following this instinct?

Nature provides winter coats for the animals that must remain out in the cold. We learned long ago to insulate our bodies partially against the cold with warmer winter clothing. Have we approached seriously the application of this idea to our buildings? We refine the artificial heating plant, spend time and dollars and skill and genius in elaborating the heat transmitting appliances and the fuel consuming devices with no more than a cursory investigation of the type of construction of the building, and with no effort to influence the construction of the building so as to reduce the heat losses.

Many of us, I believe, stand convicted of crime in this regard against future generations. There are instances available where 5 per cent. of the cost of the building, expended on heat transmission insulation rather than on a larger heating plant, saved in fuel charges alone its cost within three years. The field this opens up is almost unexplored. We know, however, how much more efficient as regards heat insulation is an ordinary sawdust packed icehouse than an ordinary dwelling, and how much longer heat is retained in an ordinary fireless cooker than in any part of the best insulated transmission department of an ordinary heating plant.

We know that poor insulation of walls and windows is the greatest enemy of good ventilation, preventing proper diffusion of the fresh air. We know that tight windows or storm sash permit of very considerable fuel savings. We know that warm winter buildings are cool summer buildings. We know that a $10,000 investment with a 5 per cent. interest charge is better for the borrower than an $8,000 investment with a 20 per cent. interest charge. We seem, however, unable to get perspective enough to use this

knowledge, else buildings with rattling windows and no storm sash, thin walls, cold attics and cellars, direct-indirect radiators, unduly high ceilings, single slab roofs, etc., coupled with the most elaborate and expensive heating plants, would cease to exist.

In our practice as engineers are we losing perspective in regard to the location in the room of the heat source? We learned, very early in our experience, that the heat transmission varies, among other things, in a certain proportion as the difference in temperature between the hot and cold objects varies. Is it then the best practice to place the hottest thing in a room against the coldest object? The dean of one of our greatest engineering schools agreed with me that in most instances the radiator location was far more a factor of the convenience of the occupants of the room than of their comfort. Granted reasonably tight windows and fairly well insulated walls, the radiator may be alongside the inside wall as satisfactorily as alongside the outside wall. May not the radiator be smaller—will not the piping be less expensive—will not the fuel cost be lower, if this procedure is carried out consistently?

Is it not a loss of perspective to cling to the idea that air for ventilation shall all have been heated prior to its entry to a room? Our belief in this is traditional. Is it based on truth? It has been demonstrated that unheated air may be introduced into rooms under certain peculiar ideal conditions, and that under these conditions the air feels better to us than air which has been heated. This process has proven good for street cars. Shall we not hope for the development of the process for buildings, so perfected that it shall operate continuously and effectively? I believe that it will surely follow the construction of properly insulated buildings, and that we cannot attain approximately perfect ventilation until we build insulated buildings.

Is our perspective normal as affecting air cleaning apparatus? Are there no other natural processes from which we may take a hint aside from the reduction in atmospheric dust after rain? Will not our progress accelerate when moisture content and dirt removal from air are seen as clearly as separate processes? Is it impossible to bring forth an air cleaner which shall operate continuously, economically and efficiently at less original and maintenance cost than the modern commercial air washer, and thus become more popularly possible? Is there no device which can do for our homes approximately what our nasal functions do for our lungs? Despite

the dust which autopsies show these cleaners have let by, are they not more efficient than any of our artificial cleaners?

I have attempted to suggest some improvements to stumble over some perspectives to be viewed.

By the friendly contact of our organization and a helping hand, many of us will stumble over desirable elements to success.

By the inspiration of this society's contact many of us may climb the heights enclosing our narrow valley and view the distant peaks of achievement in a perfect perspective. Those of us remaining, who can neither stumble or see, forming the rank and file, who are achieving genius by infinite care and pains, will always find, I hope, in the contact engendered by our organization and our meetings some alleviation of the grind of life's turmoil.

DISCUSSION

President Lewis: Since writing the foregoing an illustration has occurred to me which perhaps might be interesting. Imagine for a minute that instead of trying to heat the inside of a building against the cold outside that we were trying to cool the inside of the building with ice against the heat outside; would we put the ice against the outside wall, the hottest surface available? I doubt it. I think we would put the ice at some point where it would absorb heat from the contents of the room rather than from the hot outside walls. We would not expose one-half of each ice cake to the direct heat from the walls, in such a way as to limit its cooling influence on the room.

In the past, although we knew that less radiation was required if we did not put radiators up against the cold walls, our custom has been nevertheless to set the radiators against the cold walls. We have a committee now working on the best and most economical place in a room to set a radiator.

CCCXLVII

CAR VENTILATION

D. I. COOKE, MEMBER

The necessity for improvement in sanitation of cars particularly as regards Ventilation has long been recognized, and an examination of the files of the United States Patent Office will show that various patents on car ventilating devices have been granted since 1842. With the growth of passenger traffic on steam roads the lack of adequate ventilation has become more pronounced, and the earliest attempts toward improvement along this line were directed toward the railway passenger coach. Among the earlier systems used is that known as the Spear Stove System. This device was developed during the period when steam trains were heated by stoves in each coach, and in this case provision was made for fresh air supply by means of a duct located above the stove in one corner of the coach. This duct terminated in a scoop or cowl projecting above the roof line. The theory was that the movement of the car would induce a sufficient circulation of air over the radiating surface of the stove to relieve the car interior and provide proper fresh air supply. This system was in vogue some 25 or 30 years ago and in practice was found somewhat unsatisfactory on account of the fact that the air entering the coach admitted cinders, smoke, etc., to the car interior.

A contemporary system was known as the Winchell Ventilating System. This scheme provided for admitting the air at one end of the car under the front hood allowing it to distribute itself through the car interior and providing for an exit port at the rear hood at or near the roof line. This device was found to be in-

operative when the car was standing still, and according to Prof. Nichols, of the Massachusetts Institute of Technology, its average capacity was from 7,000 to 10,000 cubic feet of air per hour furnished to the car interior under favorable conditions.

Another device known as the Pullman Deck Sash System allowed for ventilation by means of the deck sash only. With this arrangement no provision is made for tempering the admitted air and there are no inlet ports except the deck sash proper. In this case the heating of the air is done after it enters the car and the air change produced is limited to the leakage and circulation established in and out of the deck sash openings. The earlier cars equipped with the system were lighted by lamps, and the lamp ventilators served to some extent as outlets for air from the car interior.

The passenger car ventilation in use on the Pennsylvania Railroad was developed some 10 or 12 years ago through exhaustive study under the supervision of Dr. C. B. Dudley, Chemist of the Pennsylvania Railroad, and A. S. Vogt, Mechanical Engineer, and others. This system is so designed to admit air at the car hoods at opposite corners of the roof. A vertical duct or riser is provided connecting with a horizontal duct beneath the car floor running the length of the car and leading through slots or openings in the floor to a housing around the steam pipes located above this air duct. From the housing around the car heaters, branch connections are made through galvanized iron ducts leading under each seat and terminating in inlet openings into the aisle space. A series of Globe Ventilators are located on the center line of the upper deck roof serving as outlets. This system has proven very satisfactory and under test has developed a capacity of approximately 1,000 cubic feet of air per minute with a train speed of 30 miles per hour and all ventilators open. One of the essential features of this system is provision for screening the admitted air by means of a fine wire gauze over the roof inlets. There is also provided an inlet valve capable of regulation by the train crew to regulate the air supply in combination with a butterfly valve located in the vertical riser serving to exclude smoke, etc., during operation through tunnels.

A detailed description of this system is found in a paper before the Western Railway Club by S. G. Thompson, Assistant Engineer, M.P., Pennsylvania Railroad.

The Garland Ventilator is standard for Pullman cars and consists in the application of 10 or 12 Aspirator Type ventilators located along the car roof leading into openings through the Monitor Deck space. The car movement causes a suction pressure at these ventilators and induces a flow of air outward from the car interior. This device is effective in proportion as the car speed approaches the maximum, and the circulation of air through the car interior is largely dependent upon leakage as no particular provision is made for air inlet to the car body. This system is more or less in-operative when the car is standing in the terminal, and the exhaust effect through the ventilators is largely affected by wind currents and atmospheric conditions, sometimes resulting in a back pressure at the outlet ports allowing of cold air entering at the roof line.

Dr. T. R. Crowder in a paper before the American Public Health Association in September, 1911, lays emphasis on the fact that "the vital element of ventilation problem becomes that of regulating the temperature of the air," and also states that the hygienic value of ventilating devices depends largely upon their scientific application and co-ordination with the heating system used. This point is generally recognized, and Prof. C. E. A. Winslow has stated that the value of a ventilating system lies in its ability to reduce the room or building temperature. It has been suggested that complaints regarding poor ventilation on common carriers is due to a condition of the mind; that is, the circumscribed area existing in a car impresses the occupant with a feeling of oppression or a sensation of closeness which in reality may not exist. Another point to be remembered is the fact that on account of so little being known regarding ventilation by the average public it is difficult to secure co-operation or even an acknowledgment that the efforts made are appreciated. The idea is generally prevalent that in order to ventilate a room or enclosed space it is necessary to have all windows and doors open, and it is difficult to convince the laymen that scientifically correct ventilation may be attained without resorting to this practice. Any consideration of the problem of car ventilation should, in my opinion, include a study of the best practice obtaining as regards car heating as it does not appear that the two problems can properly be disassociated. It is evident that the best results as regards heating and ventilation can only be obtained when the two subjects are considered collectively.

In connection with improvement in sanitation of street cars, the matter of ventilation has been receiving attention and considerable development work has been accomplished. It is conceded that street cars operating through the congested centers of population are a source of danger as regards the spread of infectious disease. This will be realized when the character of the passenger traffic accommodated is considered together with the relatively small air space per passenger in the ordinary city car which obtains during rush hour periods. A certain percentage of the passengers are probable disease carriers and in an infectious condition. This coupled with the fact that the entire cubic contents of an unventilated car may be polluted by a single infected passenger indicates a most unsanitary condition.

The usual method of providing for car ventilation has been to construct a Monitor Deck or clear story having a number of small windows which could be opened to allow of air entering. The ventilating value of this construction is relatively small as the windows open serve only to dilute the air in the car body; that is, air entering will freshen the air in the car interior to a limited degree. This action is not positive and does not affect the entire body of air in the car, and especially the air at the breathing zone. In colder climates it has never been found practical to operate cars with the deck sash wide open as the incoming air entering at the roof settles rapidly down on the heads of the passengers causing discomfort as well as objectionable draughts. As a result, cars of this type are generally operated with the deck sash closed and without adequate provision for ventilation.

The earlier types of street cars were usually open-end cars without vestibules, and during stops were open at front and rear allowing of the introduction of air to the car interior.

With the introduction of the Prepayment Type cars now widely used, the car construction usually includes a bulkhead at the front and rear separating the car interior from the end vestibules. The means of entrance to the car interior consists of sliding or swing doors located in the bulkhead. One of the essential features of the Prepayment car design includes provision for maintaining exit doors closed while the car is in motion, and this feature in conjunction with the fact of closed vestibules prevents a circulation of air through the car end to end as in the earlier types of cars,

and while the car is in motion the forward bulkhead serves as an air lock preventing the fresh air blowing into the car body.

In 1908 and 1909 the matter of street car ventilation was taken up by the Chicago authorities and a series of tests made under the joint supervision of the Health Department, Officials of the Street Railway Companies and the Board of Supervising Engineers.

A number of so-called Natural Ventilators were applied and tested, usually consisting of an adaptation of the Aspirator Principle. These devices depend upon the suction effect produced by passage of air across openings on the car roof, and their efficiency is directly proportional to car speed. This type of ventilator did not prove satisfactory on account of the fact that the average speed of city cars during rush hour periods is low, and the average cubic space per passenger in a city car was found to be under 25 cubic feet during rush hour periods. The limitations of such ventilating devices will be readily appreciated when it is understood that the ordinary car in city service has an average operating speed of 9 to 12 M.P.H., and when the greatest passenger load is being handled and the necessity for ventilation is most urgent, the car is operating at the lowest rate of speed with most frequent stops. Under these conditions a natural ventilator is found to be working at the greatest disadvantage and is least efficient. As the car reaches the outlying districts the operating speed increases and the ventilating device in question is operating under most favorable conditions.

It was also found that the efficiency of any natural ventilating device decreases in direct proportion as it is made weather proof. Another serious objection to such systems in practice is the difficulty of maintaining an even temperature in the car interior. In order to make a car ventilating system effective, it is essential that the exhaust effect be maintained as nearly constant as possible, as otherwise the effect on the car heating system will be to reduce its efficiency on account of the fact that a given quantity of air will be taken in at one time, and an excess quantity at another time, which results in chilling the heaters as well as rendering it impossible to heat the air passing over same. The fluctuation in the flow of air over the car heaters, a characteristic of all natural ventilating systems, is due to the variation in the exhaust or suction effect induced by the exhaust ventilators on the car roof.

The natural ventilating devices applied to city cars were found to be affected as regards their operation by atmospheric conditions,

wind velocity, car speed and direction, and the efficiency or capacity of such devices was found to be a variable quantity limited by above conditions. It also developed that such devices could not be efficiently combined with the car heating system. In the case of the Chicago situation a specific requirement or standard for ventilation having been decided upon, it developed that this class of ventilator could not be depended upon for results.

As a result of the Chicago tests an effort was made to develop a mechanical ventilating system and after consideration the exhaust system was decided upon on account of the fact that its application could be most readily made without interfering with the standard car construction and also as a more satisfactory application might be obtained. In the Fall of 1908, one of the Chicago Railways Company's car No. 102 was equipped and placed in service for test. The ventilating equipment for this car consisted in the application of a direct connected exhaust fan and motor operating in a sheet copper housing located at one end of the car of the vestibule roof. From the fan inlet a cone connection was made through the end transom space in the Monitor Deck, and an exhaust chamber space was provided in the Monitor Deck having a cross section area of approximately 160 square inches, and a minimum depth of four inches, this exhaust chamber extending the length of the car body some 31 feet. A series of outlet registers, having a six inch diameter grille, were installed in the lower face of this exhaust chamber located in pairs on approximately four foot centers. A connection was made to eight of the electric car heating units located beneath the cross seats of the car and an opening cut through the car floor having a cross section of 28 square inches each. This opening was connected with the heater coil by means of a sheet steel duct which served as the air intake connection. The cubic contents of the car body was 1,910 feet gross. The exhaust fan employed was a brass wheel of the cone type having a diameter 10⅝ inches with a 2⅜ inches width at periphery. This fan was driven by the motor operating at approximately 2,200 R.P.M., and under test the ventilating system was found to have a capacity of approximately 1,000 C.F.M. exhaust. As a result of test made on car No. 102, this system was adopted by the Chicago Railways Company, and an initial equipment of 350 cars made in the Fall of 1909. Since that time approximately 1,000 surface cars have been equipped with Mechanical Car Ventilation and are in operation in the city of Chicago. (See Figs. Nos. 1-2-3-5-6.)

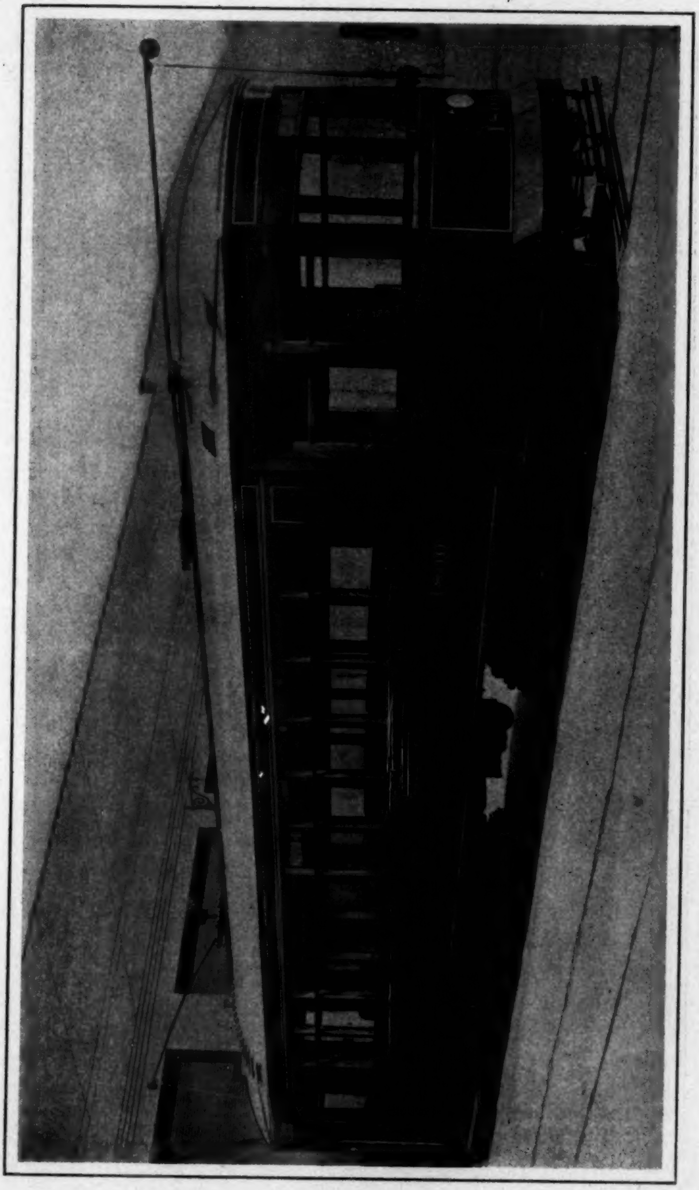


Fig. 1. Exterior of Chicago Car, showing Fresh Air Inlet Openings in car body and outlet at roof line.

Fig. 2. Interior of Car Body, showing Fresh Air Inlet connections in place before heaters are installed.

Fig. 3. Interior of Car, showing outlet register in car head lining.

In the case of the Mechanical Exhaust System in operation the exhaust fan creates a suction pressure in the exhaust chamber in the car roof resulting in a flow of vitiated air outward from the car body; which in turn induces a flow of fresh air inward over the car heaters, causing an even and constant circulation of air through the car under all operating conditions. The total area of openings provided for Air Intake and Exhaust being so proportioned as to allow of a maximum air velocity of 300 feet per minute. The car heating system may be operated independent of, or in conjunction with the ventilating system, and in the latter case the heating system operates at the point of highest efficiency and the desired car temperature is readily maintained without materially increasing the current consumption in the car heating system. This is due in part to the fact that the car heating and ventilating system operating together are, in effect, a Direct-Indirect system, and the constant flow of fresh air over the units of the car heating system serve to increase their efficiency.

Plenum systems of ventilation have been designed to operate in conjunction with car heating equipment and are widely used in Detroit, Cleveland, Pittsburg and other cities. This system as ordinarily applied consists of a coal stove having a motor driven fan operated with provision for circulating fresh air over the radiating surfaces of the stove and conducting same by means of a horizontal duct extending along the side wall of the car body beneath the seats. A series of square or rectangular gratings located in the face of this duct or plenum chamber serve as outlets for the tempered air to the car body. The combined heating and ventilating unit is generally located at one end of the car in the vestibule space. The unit is manufactured in two standard sizes rated at 250 C.F.M. and 500 C.F.M. respectively.

The disadvantages of the Plenum Systems as applied to cars in the manner described above are obvious and may be enumerated as follows:

First: The amount of space available for the installation being limited the fresh air is necessarily introduced at a relatively high velocity.

Second: A complete distribution of the heated air through the car interior is impractical with the plenum system.

Third: A specific air change is difficult of attainment on account of the fact that the air introduced at the floor line directly affects the body of air in the car body to a limited degree.

Fourth: Operating in conjunction with a coal burning stove the percentage of gaseous emanations is high and ordinary carbon dioxide determinations have little value under these conditions.

Fifth: To provide for the escape of air introduced at the floor line a series of ventilator outlets, usually of the Aspirator Type, are required to be located on the roof.

Sixth: The high velocity of air at the outlets serves to disturb and disseminate the dust particles and street dirt carried in on the car floor.

The equipment furnished for an installation of the mechanical exhaust system is designed for operation at a minimum of expense for maintenance, and the charges against the system for upkeep will be found very little in excess of the costs of upkeep of any car ventilating system. The ventilating system is furnished to comply with any requirement or standard which obtains at the present time, having a guaranteed capacity to handle a minimum of 1,000 C.F.M. through the car interior under all operating conditions. Where local conditions may require a greater capacity, equipment may be furnished to deliver same under an absolute guaranty.

As regards the characteristics of the fan and motor equipment used, the following may be of interest.

The motor has a series winding of 600 volt DC, being of the steel frame fully enclosed type operating under full load at 1,950 R.P.M. and with an ampere rating of .89. Under operating conditions with a motor speed of approximately 2,000 to 2,100 R.P.M. the motor load is about .75 amperes, and the motor operates normally on a voltage of 550 to 575 volts. Under these conditions the standard fan has a capacity in excess of 1,000 C.F.M. exhausted. In operation the motor is controlled from a snap switch carrying a three ampere fuse, and the rugged construction employed allows of operating the motor directly across the line on trolley voltage without any starting resistance. The motor is designed as regards lubrication for the use of hard oil and waste, and when the bearing housings are once packed properly, the motor will operate from six months to one year without any attention except as regards brush renewals.

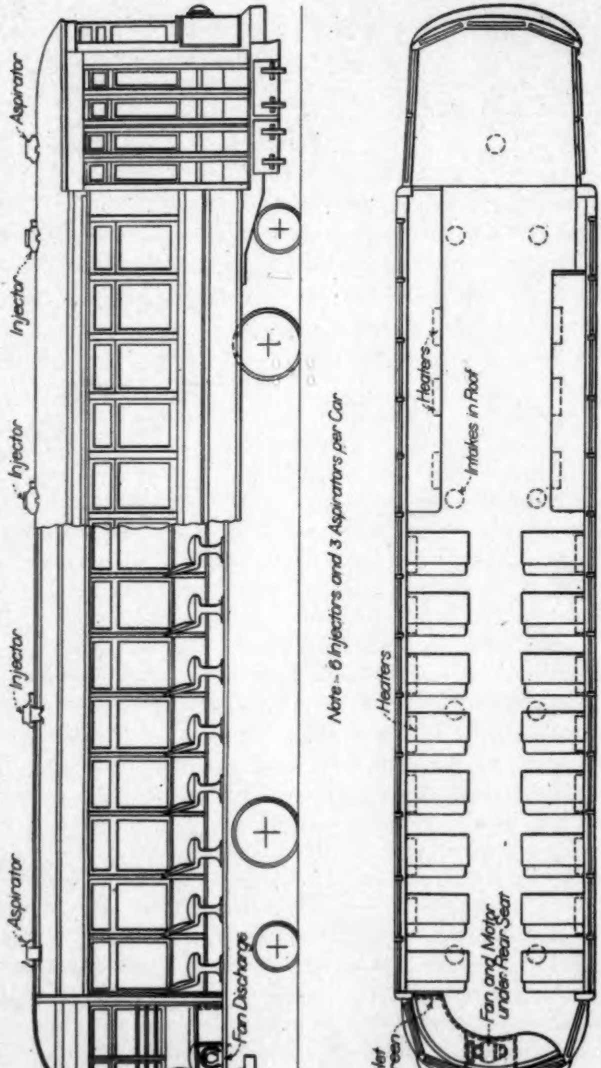


Fig. 4. Layout of Near Side Cars.

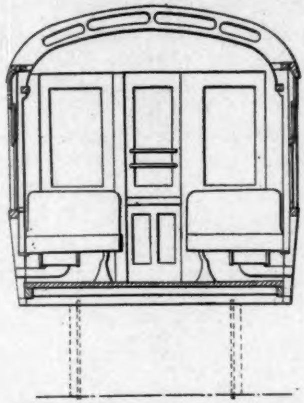


Fig. 5. End Section Chicago Car.

In practice the ventilating system is required to be operated during the heating season, which in Chicago is considered as 155 days per year. During that period of time the car is operated with the doors and windows closed, and in the winter season with storm sash fitted on the car windows. Under these conditions the ventilating system affords the only means for a constant supply of fresh air to the car body. With the car heating system, which in Chicago is of the electric resistance unit type, an increased efficiency of the heating system has been observed. In standard practice a connection is made to eight of the car heaters for the fresh air supply from rectangular openings in the side walls of the car body, and these coils over which the fresh air flows in entering the car body are found to operate at a lower coil temperature than the balance of the heaters in the circuit. The heaters in the circuit are wired in series parallel, and a decreased coil temperature results in the case of the heaters connected for fresh air supply (which are in effect tempering coils) decreasing their resistance with a consequent increase in flow of current. The reverse of this condition obtains in the case of the balance of the heaters in the heating circuit as the other units of the car heating system operate with a higher coil temperature, increased resistance and a decreased flow of current which balances the decreased resistance in the first set of coils. From numerous tests made it is apparent that the car temperature is readily maintained during operation of the ventilating system and the current consumption in the car heating system is not materially increased over normal conditions. It is to be observed in this connection that

the normal coil temperature of the electric resistance heater unit is approximately 350 degrees F., while the single units have a normal rating of 400 watt hours each.

The results of a test made to determine current consumption in the car heating system under normal conditions and during operation of mechanical ventilating system are given herewith. The ventilating system under test conditions was found to have a capacity of 650 C.F.M. exhausted and the current consumption measured under 1, 2 and 3 points of heat with the fan in service was the KWH consumption obtaining under these conditions.

TEST TO DETERMINE EFFECT OF THE OPERATION OF VENTILATING SYSTEM ON THE CAR HEATING SYSTEM, AS REGARDS CURRENT CONSUMPTION, JANUARY 4, 1911.

The results of this test, as scheduled below, indicate the fact that the circulation of air produced by the fan in operation does not increase the current consumption of the heating system.

It will also be noted that there is no appreciable effect on the car temperature. The duration of the test was not sufficient to produce the maximum car temperature, but the observations were taken extending over a long enough period of time to definitely establish the ratio of current consumption in each case. The car was started without heat and with an initial temperature of 28 degrees F. The observations were taken with the car exposed to a side wind of 42 miles per hour, which should cause a maximum radiation from the car body.

The heating system was turned on first with one point of heat and the ventilating system out of service, a series of readings being taken, and the ventilating system being later placed in service for an equal period of time. Subsequent readings were taken with the heating system under 2 and 3 points of heat, respectively, observations being made with the ventilating system both out of service and in service in each case. The results of this test are given in detail herewith. It will be further noted that during the test there were but three people in the car and that the car temperatures, as given, were indicated by clinical thermometers. The car was required to be placed in service at 4:30 P. M., and the last observation was accordingly taken at 4:26 P. M.

TEST OF HEATING SYSTEM.

In Connection with Ventilating System on Chicago Railways Company's Car No. 1013, January 4, 1911.

Time	Volts	Amperes	K. W.	Pts	Ht.	Fan	Car Temp.	Outside Temp.
1.38	450	6.0	2.7	One	Pt.	Off	28 deg.	15 deg.
1.43	450	4.5	2.0	One	Pt.	Off	34 deg.	15 deg.
1.49	450	4.5	2.0	One	Pt.	Off	36 deg.	15 deg.
1.54	425	4.5	1.9	One	Pt.	Off	37 deg.	15 deg.
1.59	425	4.0	1.8	One	Pt.	Off	38 deg.	15 deg.
2.04	425	4.0	1.8	One	Pt.	Off	38 deg.	15 deg.
2.05	475	4.5	2.1	One	Pt.	Off	38 deg.	15 deg.
Av.	442	4.42	2.04					
2.08	475	5.0	2.37	One	Pt.	On	37 deg.	15 deg.
2.13	500	5.0	2.5	One	Pt.	On	36 deg.	15 deg.
2.15	475	4.5	2.14	One	Pt.	On	35 deg.	15 deg.
2.18	475	4.5	2.14	One	Pt.	On	34 deg.	15 deg.
2.22	475	4.5	2.14	One	Pt.	On	34 deg.	15 deg.
Av.	480	4.86	2.25					
2.24	485	14.0	6.79	Two	Pt.	Off	34 deg.	16 deg.
2.25	510	11.0	5.61	Two	Pt.	Off	35 deg.	16 deg.
2.27	475	10.0	4.75	Two	Pt.	Off	36 deg.	16 deg.
2.30	450	9.0	4.05	Two	Pt.	Off	36 deg.	16 deg.
2.33	475	9.25	4.39	Two	Pt.	Off	37 deg.	16 deg.
2.35	465	9.0	4.18	Two	Pt.	Off	38 deg.	16 deg.
2.40	475	8.75	4.15	Two	Pt.	Off	39 deg.	16 deg.
2.44	450	8.50	3.82	Two	Pt.	Off	40 deg.	16 deg.
Av.	473	9.93	4.71					
2.48	475	9.0	4.27	Two	Pt.	On	40 deg.	16 deg.
2.50	470	9.0	4.23	Two	Pt.	On	40 deg.	16 deg.
2.53	450	8.5	3.82	Two	Pt.	On	40 deg.	16 deg.
2.56	475	9.0	4.27	Two	Pt.	On	40 deg.	16 deg.
2.58	450	8.5	3.82	Two	Pt.	On	39 deg.	16 deg.
3.00	475	9.0	4.27	Two	Pt.	On	39 deg.	16 deg.
Av.	465	8.8	4.11					
3.05	425	8.0	7.65	Three	Pt.	Off	39 deg.	17 deg.
3.07	465	15.0	6.97	Three	Pt.	Off	40 deg.	17 deg.
3.10	475	15.0	7.12	Three	Pt.	Off	42 deg.	17 deg.
3.12	475	14.75	7.00	Three	Pt.	Off	43 deg.	17 deg.
3.17	475	14.75	7.00	Three	Pt.	Off	44 deg.	17 deg.
3.22	450	14.00	6.30	Three	Pt.	Off	45 deg.	17 deg.
3.26	495	15.00	7.42	Three	Pt.	Off	46 deg.	17 deg.
3.34	490	14.75	7.22	Three	Pt.	Off	47 deg.	17 deg.
3.43	475	14.75	7.00	Three	Pt.	Off	48 deg.	17 deg.
3.50	450	14.00	6.30	Three	Pt.	Off	50 deg.	17 deg.
Av.	467	15.00	6.99					
3.55	450	14.00	6.30	Three	Pt.	On	49 deg.	17 deg.
3.58	495	15.00	7.42	Three	Pt.	On	49 deg.	17 deg.
4.05	450	14.00	6.30	Three	Pt.	On	48½ deg.	17 deg.
4.10	450	14.00	6.30	Three	Pt.	On	48½ deg.	17 deg.
4.14	460	14.25	6.57	Three	Pt.	On	48½ deg.	17 deg.
4.22	375	12.00	4.50	Three	Pt.	On	48½ deg.	17 deg.
4.26	475	15.00	7.12	Three	Pt.	On	48½ deg.	17 deg.
Av.	450	14.03	6.35					

An interesting application of Mechanical Ventilation to 125 single end operated cars of the Near-Side Type operating over the

lines of the Chicago City Railway Company was made during the year 1913. Ordinary practice in installation of Mechanical Car Ventilating Systems has heretofore contemplated means for introduction of fresh air over the units of the car heating system to obtain a tempering effect on the air entering the car body to replace the air exhausted by the fan. In the case in question the cars being already in service it was decided that the application of the standard system would be impractical on account of expense involved in changing the car construction as well as the loss of car service resulting from such changes. (See Fig. 4.)

The cars were originally equipped with nine natural ventilators of the Aspirator Type located on the car roof with a series of openings through the car floor beneath the truss plank electric heaters located at the side walls of the car. This system proved unsatisfactory in operation on account of the street dust taken into the car interior through the floor openings beneath, and it was also found impossible to secure the desired car temperature during colder weather. Accordingly, six of the Aspirators were converted into Injectors located on the roof, the openings beneath the car heaters in the floor were closed and a motor driven exhaust fan was located beneath the end seat in the rear of the car discharging downward through an opening in the car floor. The fan was housed in beneath the seat having a screen inlet opening of approximately one square foot superficial area. The motor used had a capacity of ½ H.P., 600 V. with a normal operating speed of approximately 2,000 R.P.M. under service conditions with a voltage from 550 to 565. Under these conditions the cone fan having a diameter of 10⅝ inches, width at periphery of 2⅜ inches had an exhaust capacity of 1,000 C.F.M. The roof injectors under an average operating speed of 9 M.P.H. served to introduce a minimum of 500 C.F.M. to the car interior and during operation of the car the balance of the air handled by the fan entered the car through leakage points, cracks around doors, windows, etc. When the car stopped and the forward door opened the roof injectors ceased to become operative and the air movement is set up longitudinally through the car end to end. Due to the large area of openings at the front doors the air entered at the rate of 1,000 C.F.M. at a very low velocity and without perceptible draughts. As soon as the doors are closed and the car set in motion the fresh air is forced in at the roof injectors aided by the suction pressure of the fan.

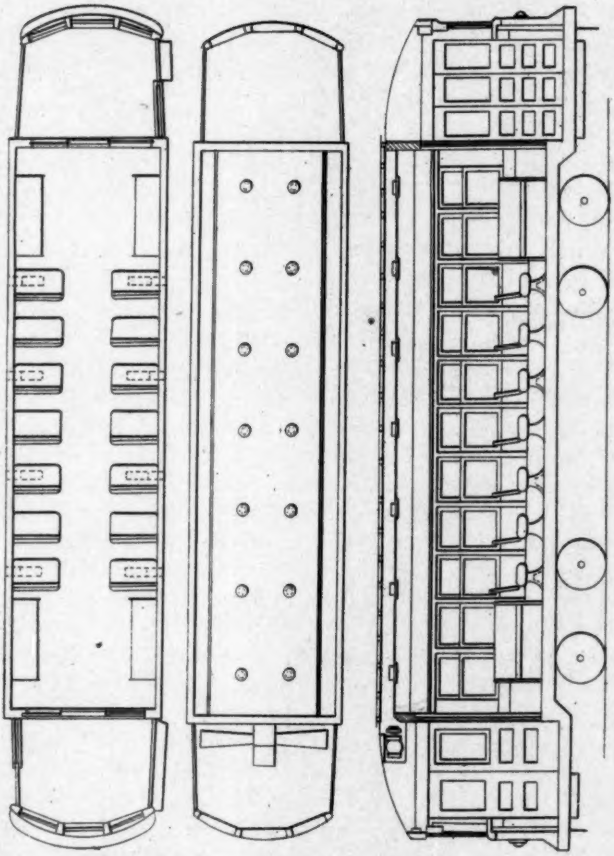


Fig. 6. Standard Plan for Chicago Cars.

This ventilating system, in operation on 125 cars, proved to be very satisfactory.

First: As regards the effect on the car heating system, it was found that the car temperatures as provided by ordinance, of 50 degrees in zero weather, were maintained without difficulty.

Second: The effect of the ventilating system was very satisfactory on account of the positive circulation of air established through the car interior, and the absence of dust in the air supplied.

Third: The "primary sense impression" noticeable on entering the car when same was loaded to capacity was most pleasing on account of the sensation of freshness in the air at the upper level of the car.

Fourth: The fresh air was delivered to the car directly at the breathing zone or upper level.

Fifth: The heated air was forced to the lower level of the car where the most effective results are obtained.

Sixth: The fresh air entering at the roof line diffused and mixed with the rising currents of fresh air from the heaters and aided by the suction pressure of the fan resulted in an even stratum of fresh tempered air longitudinally through the car at the mid section.

As a result of this installation my opinion is that direct contact with the units of a heating system for the fresh air supply is not necessary, and in fact it is my belief that in many installations conditions would be improved by the introduction of fresh air at low velocities at points considerably removed from the source of heat or radiating surfaces. It is evident that due to the differing densities of outside cold air and air radiated from the heating surface a thorough diffusion and mixing effect may be attained. The primary advantage of such arrangement lies in the fact that fresh air may be delivered directly to the breathing zone with a revivifying or exhilarating effect, a relatively lower temperature may be maintained in the room or enclosed space while equally satisfactory results will be secured as regards the desired heating effect. It is my opinion that with such arrangement the amount of heating surface for a given installation may be somewhat reduced with a consequent reduction in fuel consumption over that required in an ordinary direct-indirect system.

Since the development of the mechanical car ventilating system a radical change has taken place in car design as regards the roof construction. Some 20 or 30 years ago the idea of a plain Arch Roof was conceived and introduced but not found to be practical

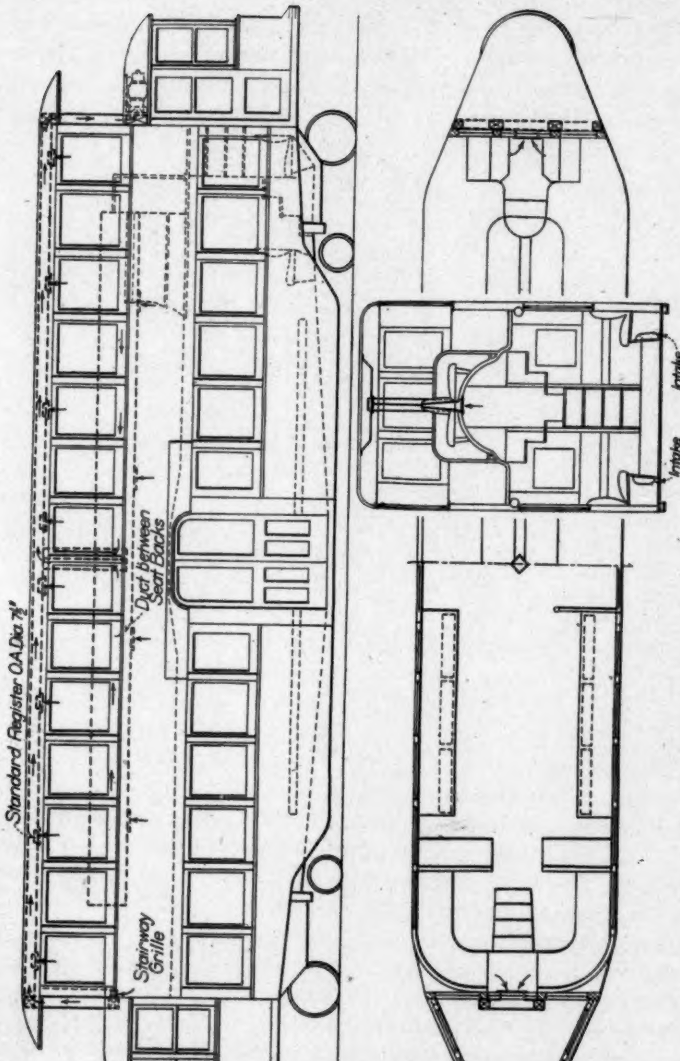


Fig. 7. Layout for Double Deck Cars.

on account of the difficulty of obtaining proper ventilation. Since that time the use of the Monitor Deck Roof with the small windows has been general. The mechanical exhaust ventilating system in its application to the Arch Roof car being entirely practical and presenting many advantages, this type of car has now become generally used.

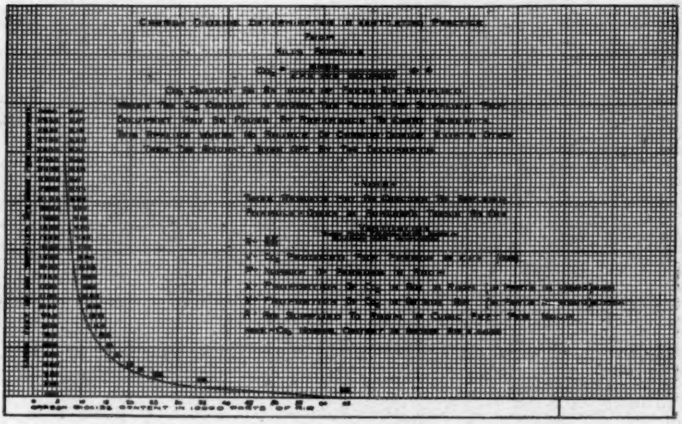
The mechanical exhaust system of car ventilation has been applied during the last two years to the Double Deck cars which are being operated experimentally in the cities of New York, Washington and Columbus. The installation of the exhaust system is made as follows: An exhaust chamber space is provided in the car roof in the upper deck having a cross section of 5x40 inches. In the lower face of this exhaust chamber is located a series of six inch diameter register faces or grilles to serve as air outlets from the upper deck section. The space between the seat backs in the upper deck forms the sides of a triangular duct of which the arch across the lower deck forms the bottom. This duct serves as an outlet from the lower deck section and is connected with the main exhaust chamber in the upper deck roof by means of a riser at the mid section. A series of outlet registers is also located in the lower deck roof opening into the triangular duct described above. The main exhaust chamber in the upper deck roof terminates in a header at one end of the car body to which in turn are connected four risers extending vertically downward along the window posts and having a cross section of 6x6 inches each. These vertical risers connect to a header in the cab roof in the lower deck and an exhaust fan and motor is connected into same at that point.

Fresh air inlet connection is made to the car heaters in the lower deck section and with the exhaust fan in service a circulation of air is established through the upper and lower deck compartments. A typical layout for installation of the mechanical exhaust system as applied to a double deck car given herewith. (Fig. 7.)

The local requirements for car ventilation obtaining in Chicago may be said to constitute up to the present time a standard. During the years 1909, 1910, 1911 and 1912, a 500 cubic foot per minute capacity outfit was used, but since that time due to the investigations made by the Chicago Commission on Ventilation and others, these requirements have been increased to 1,000 cubic feet per minute based on a carbon dioxide maximum content of 12 parts in 10,000. The average passenger load is taken as 80 passengers, 12 parts of carbon dioxide requiring an air supply equivalent to 750 cubic

feet per hour per passenger or a total of 60,000 cubic feet per hour per car.

We give below carbon dioxide chart showing relation between carbon dioxide content and fresh air supply per occupant which may be of general interest:



This chart has been made up using formula as given in Ruhloff's thesis on Car Ventilation.

The ordinary practice in vogue for conducting tests on car ventilating equipment consists of the use of anemometers to determine the air quantities, carbon dioxide determinations as a check against the air supply, Petri Dish exposures to determine bacteria content, dust determination, etc. In general the matter of testing car ventilating equipment is one which depends upon the application of knowledge of chemistry rather than mechanics and as such the writer is not qualified to discuss same from a technical standpoint.

There is an increasing interest in the matter of improvement in sanitation of cars as regards ventilation, and the various Health Departments, Public Service Commissions, Electric Railway Officials and others are investigating the matter with the idea of formulating standards which will govern in various localities.

Of the descriptive matter available regarding Car Ventilation may be mentioned:

Articles on Car Ventilation, by W. A. Evans, M.D.

Studies on Sleeping Car Ventilation, by Thos. Crowder.

Car Ventilation, a thesis, by W. C. Ruhloff, University of Wisconsin.

Records of Tests on Car Ventilation, by Chicago Railways Co., 1909-12.

Hearings on Car Heating and Ventilation, N. Y. Public Service Commission Case 1426.

Developments in Car Heating & Ventilation, by L. C. Ord, C. P. Ry. Co., from paper before Canadian Railway Club, October, 1911.

Report of Master Car Builders Association on Ventilation.

DISCUSSION

Mr. Lewis: I would like to call particular attention to one statement in Mr. Cooke's paper on the advantage to comfort of having unheated cold air introduced above the heads of the occupants. That is rather radical, but is entirely in keeping with most modern research on the line of ventilation, and seems to be one example of where it is successful. I can cite another case of an old school house heated by direct ventilation similar to the so-called Pullman ventilators in windows, so that the cold air came in over the top of the ventilators. It is a most impossible building most of the time, but when the wind comes just right I have never seen any building as pleasant and comfortable as those rooms in which the cold air is blown through the openings in those windows.

Chairman Allen: This matter of car ventilation is a very interesting subject, and especially so because we have had so little information in past years. As to Mr. Lewis' remarks on fresh air from the outside there is no question but that fresh air has a revivifying effect that you do not get from heated air although the heated air may be just as pure and fresh as the air coming from the outside, it certainly does not have the same effect upon the human body.

That is a question that is a very important one so far as ventilation is concerned. A good many physicians have claimed that in hospitals ventilated with fan systems where the air comes over hot steam coils that the patients do not thrive so well as where they take air direct from the outside. After all, outside air ventilation may have certain qualities that you do not get from air heated by coils.

Secretary Blackmore: In reading the paper the suggestion Mr. Lewis spoke of appealed to me strongly, that if the fresh air could be brought in without one's feeling a draft one could readily see what an advantage it would be. The cool fresh air forces the hot air downward and away from the breathing zone; it also carries the odors of the body downwards. The carrying of excess heat and odors below the breathing zone is very desirable, and has not been given sufficient attention heretofore.

A Member: It occurs to me that inasmuch as the results from introducing the fresh air from the ceiling have been beneficial as Mr. Cooke says—and I think he has given it as much or more study than anybody else—I would like to suggest that they take the exhaust fan and use it as a supply fan to bring the air from the floor of the car.

Mr. H. M. Hart: The more positive the quantity of air supply and the better its distribution, without any increase of cost, the better. I think there is an objection to exhausting air from the bottom of the car at one point with a fan. I notice in cold weather in some of the street cars in Chicago, where they have used this system, people have to sit over or near this exhaust outlet or fan, and it creates unpleasant cold drafts on the feet. If the air was taken out above or at more numerous outlets and at slower velocities I do not think that those cold drafts would be so perceptible, and I think better results would be obtained.

Secretary Blackmore: I would like to ask Mr. Hart how his suggestion would work when the car was still?

You would have quite a plenum condition in the car.

Mr. H. M. Hart: You would under all conditions, at all times; in other words, it would be a reversal of the Cooke system. The Cooke system provides numerous inlets near the floor line and numerous outlets at the ceiling, instead of the exhaust system it makes it a plenum system with numerous outlets in the floor. I know that such a plan has been tried, and I would like to hear from Mr. Cooke what he can tell about it.

Mr. Cooke: That proposition was tried out experimentally, and the principal objections were the difficulty in heating the incoming air. The use of the Plenum System with the standard car construction made it necessary to introduce the fresh air at a relatively high velocity, and without a direct contact with the units of the car heating system it was thought that cold drafts of air would be objected to by the traveling public. For this reason the idea was given up.

In regard to using the syphon principle for removal of the vitiated air at the floor line, the same objection would apply as in the case of ordinary natural ventilators or aspirators. Every device of this character which has been tested has been found to be inoperative during the greater part of the time the car is operated. This is due to the fact that the maximum street car speed does not exceed 9 to 12 miles per hour, while in the case of natural ventilators applied to steam passenger cars, you have an operating speed of 25 to 40 miles per hour. The street cars make 8 to 10 stops per mile during rush hour periods operated at a relatively low speed. Under such conditions none of these aspirators would give the desired effect, and for this reason fans have been considered essential.

Mr. H. M. Hart: It does not make any difference whether a car is in motion or not, the air is going to get out. Now you use an exhaust fan for moving a certain volume of air unheated through the Near-Side cars. Do you not?

Mr. D. I. Cooke: In connection with the Near-Side single end cars the standard application of mechanical car ventilation was not considered practical for that type of car as it necessitated taking the car out of service for a considerable time and also rebuilding the car roof to obtain the necessary exhaust chamber space. This ventilating installation referred to by Mr. Hart was not considered ideal when the cars were equipped, but the City Authorities now claim these cars are well ventilated on account of the fact that air comes in directly to the breathing zone. Such an installation would not be applicable to a double end car, and it has not been considered feasible to apply this installation to cars which change ends at the end of the route as in the case of the standard prepayment type of car. Installation of ventilating equipment on cars is difficult because of the limited space allowable. In fact, we are only allowed a maximum depth of four inches for the exhaust chamber in the car roof in the case of the standard system. In this case we make contact with the heater coils at the floor line for the fresh air supply.

The car companies have already made certain distinct changes in the car construction to accommodate the ventilating equipment, but a reversal of their present procedure as regards placing the car heaters at the roof line would not be regarded favorably by them.

Chairman Allen: The introduction of mechanical ventilation has resulted in a decrease in the cost of car construction, has it not?

D. I. Cooke: Absolutely so. It has also resulted in a decreased weight amounting in some cases to 200 pounds per car. The estimated cost of carrying dead weight on a street car is figured at approximately five cents per pound per year.

We considered introducing the fresh air at the roof line without direct connection to the car heaters, but on account of the rapid velocity of the incoming air it was thought impracticable. In the case in question the present exhaust chamber was converted into a Plenum chamber, and the fresh air blown in downward through fourteen ceiling registers. In this case the air pressure was depended upon to take care of the air movement outward from the car interior.

Another reason, this scheme was thought impractical on account of the weight of the units of the car heating system being such that it would be difficult to properly support them with the present roof construction. Another objection was that such a change would interfere with the present appearance of the car interior. Street car companies are exceedingly jealous of the appearance of cars that they pay from $6,000 to $7,000 apiece for, and anything that you propose to install which interferes with the interior finish or appearance is considered very objectionable.

The matter of car ventilation is a peculiar proposition in that we are attempting to supply something for which there is as yet little demand. Street car companies do not, as a class, regard the question of car ventilation as one of importance and are not anxious to incur the added expense necessary.

Mr. H. M. Hart: You must remember that people in street cars are dressed in their outdoor clothing and if their feet are warm they will not object to the draft of fresh air as long as the average temperature of the car is reasonable, and as they are dressed in their winter clothes and have their hats on they do not expose their bald heads. I think that is one condition that prevails in a street car which would never apply to a theatre.

Mr. S. R. Lewis: I believe that we are about to stumble on something. Years ago when we first began to know Dr. Evans, health commissioner of Chicago, we thought he was impracticable. The more we came into contact with him, the more we came gradually to appreciate the quality of the man and the sane ideas which he had about ventilation. His first idea was

that the proper way to ventilate a room was to open a window from the top and let the cold air in so that the cold air would be tempered by the heated air normally at the ceiling to a point where it would not be objectionable and cause drafts. This way of ventilating, when it works, seems to approach ideal ventilation. One criticism that has been made against modern ventilation is the tightness of the building construction. These steel cars are practically tight. The cold air coming in through these various openings mixes with the air already at the car ceiling warmed by the direct heaters, until there are no very great drafts and we are comfortable. The exhaust system in an ordinary room with ordinary leaks is most uncomfortable because of the cold air coming in through the cracks. It has never been proven but that the exhaust system in an entirely tight room will give us very much better ventilation than in the plenum system, because of the fact that the air may be introduced in very many places at low velocity, which is impossible with the plenum system, especially when the air handled by the plenum system has been already heated.

Mr. H. M. Hart: Anybody getting into a car can tell in a minute whether the fan is running or not, he doesn't have to look at the switch. The public when they get into that kind of a car all demand ventilation. The car people realize that they have to give it to them.

CCCXLVIII.

ELECTRIC HEATING AND ELECTRIC HEATER CONTROL

WILLIAM S. HAMMOND, JR.*

The highest efficiencies in such apparatus as steam boilers, steam engines and electric motors are attained in large and well proportioned units. In electric heating, however, large and small heating units are equally efficient and for this reason electric heaters readily adapt themselves for use in locations widely separated and in which small amounts of heat are required. Dividing electric heat into a large number of small units does not, therefore, mean loss of efficiency. For this reason electric heaters are admirably adapted for the heating of trolley cars where we have a very large number of widely scattered units all heated from one central station.

The high efficiency of electric heaters is due to the fact that the electric heater is the only form of translating device in which 100 per cent. efficiency is realized. It is well known that energy is indestructible. It is wholly converted in every translating device. It is true that translating devices generally convert energy into several forms and, therefore, any one form of energy contains less than the whole. Electrical apparatus generally transforms into the desired form of energy less than 100 per cent. Now if the theory of the conservation or persistence of force is true, all of the energy can be accounted for in some way. Let us examine, for a moment, the forms of energy into which electricity may be converted, first, mechanical motion; second, chemical action; third, light; fourth, magnetism and fifth, heat. This list, I believe, comprises all possible forms of power into which electrical energy may be transformed.

*Non-Member. Vice-President Consolidated Car-Heating Company.

By reference to the diagram, Fig. 1, I have attempted to show you some of these transformations.

100 UNITS OF ELECTRICAL ENERGY TRANSFORMED.

By	Electrolysis.	Motor.	Lamp.	Elec. Heater.
Mechanical Action.....	..	90	..	..
Chemical Action	50	..	..	..
Light	..	..	10	..
Magnetism	..	2	..	..
Heat	50	8	90	100
Total	100	100	100	100

I have assumed that we transform one hundred units of electrical energy by different devices. For example, in the process of electrolytic decomposition, the object is to produce a chemical action in the electrolyte. This we may assume to be a solution of sulphate of copper in a vessel in which are copper electrodes. When we send a current of electricity through this electrolyte, there is considerable resistance offered. This means that a certain part of the energy of the electric current is transformed into heat in the electrolyte. This heating effect takes place absolutely independent of the chemical action and consumes a certain part of the electric energy. The proportion of the electric energy so employed, which is transformed into heat depends upon the resistance of the electrolyte; it being very important that this resistance be made as low as possible. As an average condition of the resistance of electrolytes, I find that about fifty per cent. of the electric energy employed in electrolytic decomposition is transformed into heat in overcoming the resistance of the electrolyte itself and the remaining fifty per cent. is transformed into chemical action. Out of 100 units of electrical energy employed in the operation of electrolysis, we find that no mechanical motion is produced, chemical action fifty per cent., no light, no magnetism and fifty per cent. of heat is produced, or a combined total efficiency of 100 per cent. If we take the electric motor, we find that it is impossible to build an electric motor without resistance, and when a current passes through this motor we always obtain heat. Therefore, in 100 units of electric energy which are transformed in the motor, ninety per cent. approximately, may be transformed into mechanical motion, no chemical action is produced, no light, two units transformed into magnetism and eight units in the form of heat, giving us a total of units of energy in these different forms of force of 100, or exactly equivalent to the number of units of electrical energy with which we started. If now, we consider the incandescent

electric lamp and transform 100 units of electrical energy, we find no mechanical motion is produced, no chemical action, about ten per cent. in the form of light, no magnetism and ninety per cent. of heat. Of course it is apparent that the so-called efficiency of each of these transformations depends upon the useful work which we are endeavoring to produce with the electric current. If it is the electric motor, ninety per cent. is realized. If the incandescent lamp, ten per cent., although, if we were using the incandescent lamp as an electric heater, we would call its efficiency ninety per cent., instead of ten per cent. We then come to the transformation in an electric heater. Again, we will employ 100 units of electric energy. We find that there is no mechanical motion, there is no chemical action, no light, no magnetism. Heat, therefore, must be the only form of energy into which the 100 units of electric energy have been transformed. The electric heater, then, is the only case that comes within our knowledge where 100 units of electric energy may be transformed into 100 units of any other one form of force.

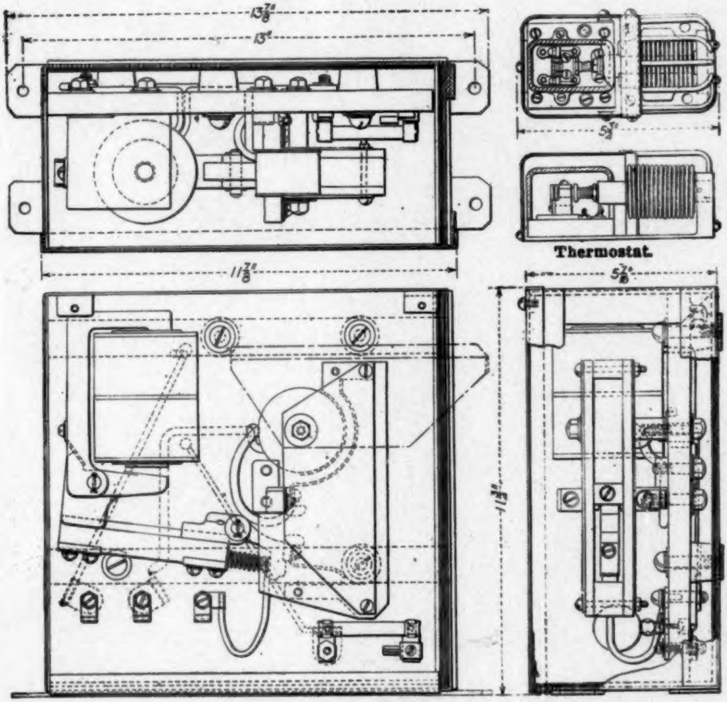
The fixed relation between electric energy and heat makes it easy to determine the amount of electric energy which is equivalent to a unit of heat. Careful tests have determined upon 1,047 watts as equivalent to one British Thermal Unit, or one pound degree F. Therefore, it becomes an easy matter to determine the exact amount of heat which is produced in electric heaters when the consumption of current is known. For example, if we find the number of watts, by multiplying the number of amperes passing through the heater by the difference of voltage of the heater terminals and then divide the number of watts by 1,047, we will have for a quotient the number of British Thermal Units of heat generated in the electric heater per second. If we consider the electric heaters in a car to be using as a maximum 12 amperes of current on a 500 volt circuit, we will find that 12 amperes of current multiplied by 500 will give us 6,000 watts. Dividing 6,000 watts by 1,047, we obtain 5.73 British Thermal Units of heat generated in the car per second. Multiplying 5.73 British Thermal Units by 60 will give us 343.8 British Thermal Units per minute. This is equivalent to 20,628 British Thermal Units per hour; or, since a British Thermal Unit is the amount of heat necessary to raise one pound of water one degree F., the heat generated per hour would be equivalent to the raising of 20,628 pounds of water one degree F. In this way, with a given consumption of current, it

is very easy to determine exact values in heat units, or if we know what heat units are required, it is a simple matter to ascertain the exact consumption of electric energy necessary to produce this amount of heat by means of the electric heater. I think that practical experience in the heating of cars has demonstrated that it requires about 20,000 British Thermal Units per hour to properly heat a twenty foot car body in the latitude of New York State in the coldest weather and that this amount of heat should be provided as a maximum. The average requirements during the months of the winter when heat is used would not exceed one-half of this amount or would be less than 10,000 British Thermal Units per hour.

The amount of heat required to heat a car differs somewhat according to the design of the car and the material of which it is constructed. Cars of steel construction require at least 30 per cent. more heat than a car made of wood, having the same capacity.

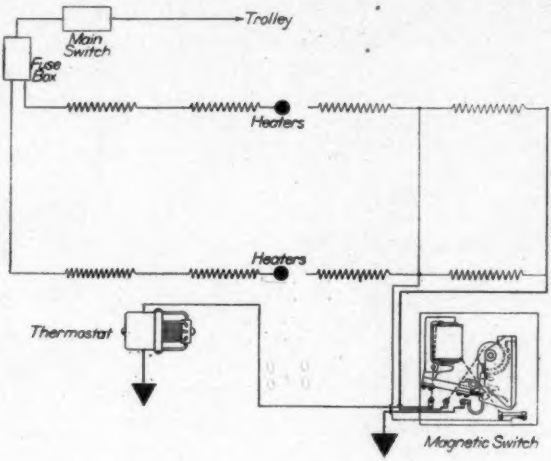
The amount of heat required depends upon the exposure to winds on lines where they are run and to the care exercised by conductors in closing the doors promptly when passengers enter or leave the cars. These conditions affect materially the temperature which will be maintained in a car by a certain amount of heat.

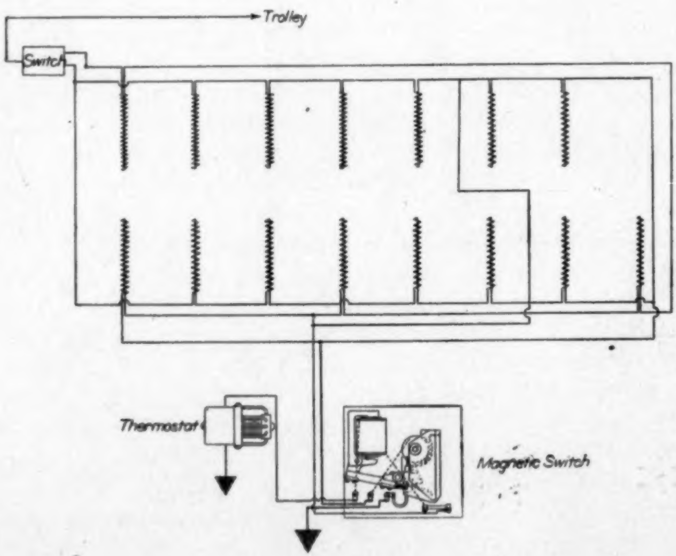
The number of people in a car affects quite perceptibly the amount of heat required, due to the amount of heat given off from the bodies of passengers. The normal temperature of the human body is 98 deg. F. The proper temperature in a car does not exceed 60 deg. F., so that each person affects the temperature of a car in a manner similar to a hot water radiator whose temperature is 38 deg. F., above the surrounding air and whose surface is equal to the surface of the human body and is partly covered by cloth covering similar to the coverings of clothing of the human body. Tests seem to show that the body of a man gives out twice as much heat as that of a woman. The amount of heat given off depends upon the temperature of the surrounding air and is proportioned to the difference between the temperature of the air and the temperature of the body. Twice as much heat is given off by the human body in air at a temperature of 22 deg. F., as is given off when the temperature is 60 deg., thus 98 deg.—22 deg. equals 76 deg.; 98 deg.—60 deg. equals 38 deg. The heat given off is, therefore, in the proportion of 76 deg. to 38 deg. or twice as much. External temperature and the character of clothing worn have

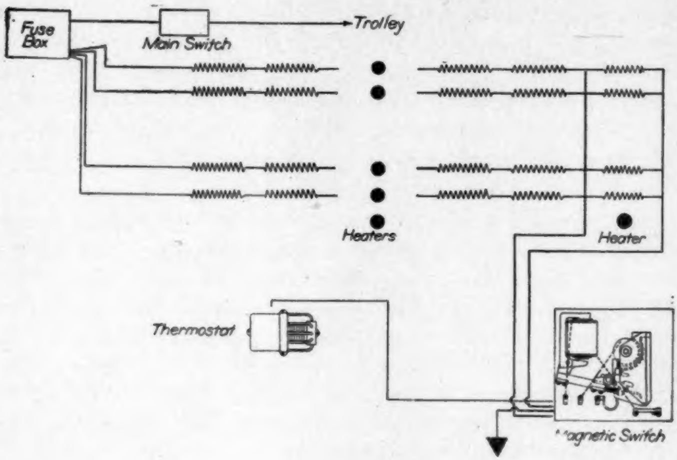


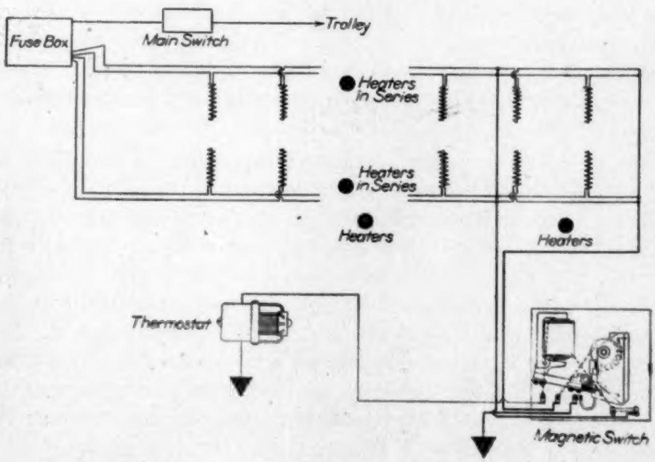
Thermostat.

Magnetic Switch.


Trolley
Main Switch
Fuse Box
Heaters
Heaters
Thermostat
Magnetic Switch


Trolley
Switch
Thermostat
Magnetic Switch


Fuse Box
Main Switch
Trolley
Heaters
Heater
Thermostat
Magnetic Switch


Fuse Box
Main Switch
Trolley
Heaters in Series
Heaters in Series
Heaters
Heaters
Thermostat
Magnetic Switch

so entered in the result of tests that the records of the heat given out by the human body varies from 198 B.t.u. to 400 B.t.u. per hour.

If now we take a car which requires 10,000 B.t.u., per hour to maintain proper temperature, it will be seen that at the rate of 199 B.t.u., per person per hour, that 50 people will give out as much heat as is required to heat the car.

This point has a practical bearing in heating cars by means of electric heaters, in that, if heat is supplied to a car at a uniform rate it will be found to be overheated during those hours of the day when the cars are filled with passengers. Some roads have established the practice of reducing the heat between certain hours when their cars are filled with passengers. This practice allows a comfortable degree of heat to be maintained in cars, at the same time it allows the use of the extra power for propelling cars at the time when travel is the heaviest.

Automatic regulation of temperature of cars, which we are now introducing, very nicely takes care of the hours of heavy travel by automatically cutting off heat during the rush hours and restoring heat when the cars cool down below the normal.

Thermostatic regulation has proven itself to be a great economic feature of electric heating. It more than saves its cost every year. Where thermostats are not used the tendency is for the conductor to turn on the heat and then forget about it. The amount of heat and the length of time current is on have but little to do with the actual requirements. When the car becomes very hot and a passenger complains about it, the conductor proceeds to cut the heat all off and to open up extra ventilators. The result is a wide variation in temperature and an extravagant and useless waste of power.

The introduction of the thermostat for regulating electric heating circuits at once corrected the unevenness in temperature of cars and, at the same time, affected a saving in current varying from forty to sixty-six per cent. The greater saving being obtained in cities like New York, where the Board of Health, having the authority to fix the limits of temperature to be maintained in cars by heating apparatus, fixed the limit at 40 deg. to 45 deg. F. The forty per cent. saving was secured on cars where the thermostat is set to maintain a temperature of 53 deg. to 58 deg., the switch being cut out at the higher temperature and the circuit restored at about 53 deg.

A modern car is constructed of glass and steel and moves through the air at such a high rate that changes in temperature take place quickly. A change of four degrees will, therefore, take place in from ten to fifteen minutes and this is considered as frequent as it is desirable to have the main thermostatic switch operate. It will be understood that with electric heating circuits the moment the temperature reaches the upper limit, the thermostat causes the magnetic switch to open and the heating current to be cut off. At once heat ceases to be generated and costs for current stop. When the car has cooled about four degrees the thermostat causes the main heater switch to close, the heaters warm up and the temperature of the car rises. This operation is repeated as often as it is necessary to maintain the temperature of the car within the prescribed limits. A thermostat to regulate heat from electric heaters differs from that used in house heating to regulate the dampers of a furnace or hot water or steam heaters, in that when the fire is burning vigorously and the dampers are operated, it takes considerable time before the flow of heat is affected. The processes of combustion will continue and temperature will continue to rise for some time before the room feels the checking effect of the thermostat. It also requires time to revive the fire after the thermostat reopens the dampers. With electric heaters, however, the control of the thermostat is instantaneous and there is no lag of the generation of heat behind the movement of the thermostat. The result is a promptness and perfection of control of heat not realized by the use of apparatus ordinarily used in house heating.

The cost of electric current makes up almost the entire cost of electric heating. It is, therefore, necessary to consider carefully the economic use of current in deciding upon any particular plan of heating or ventilation which we desire to introduce.

The ventilation of cars is always a vexed question. So much depends upon the construction of cars, the exposure in runs to high winds, the rules as to opening both forward and rear doors, the habits of the conductors in closing doors promptly when passengers enter or leave the cars, that no hard and fast rules can be made as to what auxiliary ventilation should be provided. The rapid motion of cars drives air through every crevice. The body of the car is one continued line of sash, all provided with openings, overhead, running around the car is a line of deck sash, each sash made to rock or swing, and all loosely fitted into a frame.

Doors fit loosely and provide numerous opportunities for the admission of air. Ventilation through all these sources was considered as abundant for many years. However, some new problems in ventilation have been introduced in late years, owing to the use of steel construction and to a closer and more perfect construction of car body, closer fitting sash and double windows for winter use.

HEAT LEAVES A CAR IN TWO WAYS:

1st: By warmed air which escapes through openings through ventilators, etc. This means that air which leaves a car is replaced by fresh air which must enter at some other point. This tends to keep the air pure and to ventilate the car.

2nd: Heat escapes from a car by radiation through glass windows and by conduction through windows and car walls. Heat escapes to the outside air but the inside air does not escape. The inside air grows cold but remains inside the car. This loss of heat does not ventilate the car but tends to make the air in the car impure and cold. It would be better if the escape of heat by conduction through the walls could have taken the air with it.

I regard as of first importance that there should be better heat insulation in the walls and ceilings of cars so as to stop as much as possible the loss by conduction of heat. Use double windows, not so much to prevent air leaks as to provide a dead air space between windows through which heat will not conduct readily. Double glazing of windows is known to save 33 per cent. of the heat escaping through single glazed windows.

Professor Carpenter records a test of a building where 39 per cent. of heat escaped in the ventilation flues and 61 per cent. passed by conduction through walls and windows. (Heating and Ventilation of Buildings, page 72.) If such a large percentage as 61 per cent. of the heat in a car escapes by conduction through the walls and windows, there would appear to be good reason for studying the problems of conduction through walls of cars to the end that this large loss of heat may be prevented.

I am of the opinion that direct radiation should be provided to compensate for the heat losses through the walls and windows of cars amounting to about sixty per cent. of the total heat and that the remaining forty per cent. of the heat should be supplied by direct indirect radiation, that is by heaters exposed in cars but receiving air from the outside. Air should be drawn into a car over the heating elements preferably in small units. The source

of power for causing the flow of air should be an exhaust fan operated by an electric motor.

I illustrate a form of electric heater, which has been in use for many years and it has a form of winding which has survived the trials and tribulations of actual service.

I may use this heater to illustrate points of construction which experience has shown to be essential in a successful heater.

Cars are in operation in which over two miles of bare wire are used in the construction of the electric heater equipment. This wire is supported upon an insulated core in such a manner that neighboring turns of wire have such a small difference of electro motive force that the wire may be short-circuited by throwing a handful of nails upon the heater without causing a spark to burn the wire. The two miles of bare wire are so insulated that no vibration can take place and there is no danger of grounding any portion of the circuit although large numbers of these heaters are in use on trolley circuits of as high as 1,500 volts.

It is well known that wire expands with heat. The maximum expansion of the heating wire in the equipment above referred to is over thirty-five feet. Contraction takes place again when the circuit is cut off.

It was part of the problem of constructing the successful electric heater to support the two miles of wire so that under no circumstance can neighboring turns come in contact with each other and to support it so that jarring of a car cannot disturb the winding. It was also a serious part of the problem to provide for the 35 foot expansion and contraction of the wire which took place every time the heater switch is operated.

In this heater the spring of the coils not only holds the coil to the supporting insulator, but also takes up the expansion and contraction without disturbing the position of the coil on its support.

The indestructible character of this heater is due to the large amount of heating surface and to the open winding which exposes the wire freely to the air so that heat escapes readily.

A number of metals are used in constructing the wires of electric heaters. Iron wire is used more extensively than all other wires put together. When a very high resistance is desired wires of nickel and chromium or nickel and copper are found to give good results. Wires containing zinc are not suitable for use in electric heaters because of the tendency of the zinc element to melt at a

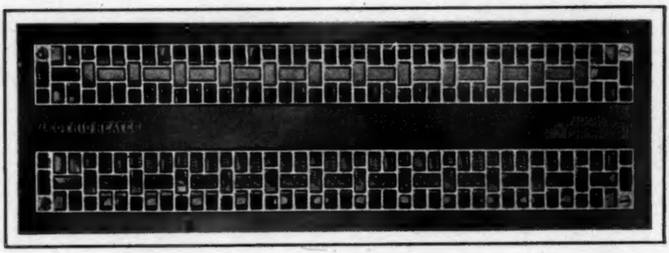
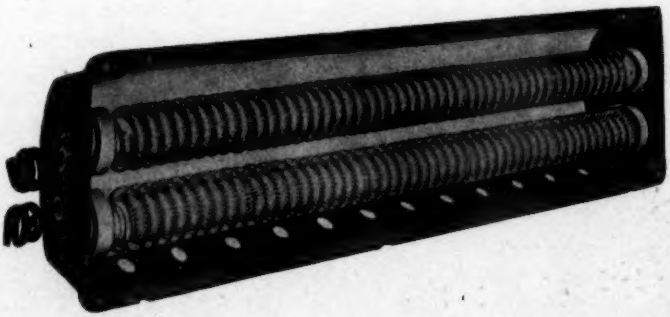


Diagram of Wiring Without Thermostatic Control.

8-Heater Equipment



high temperature and then to segregate and crystallize. In a short time the wire separates and the heater becomes useless.

Crystallization of zinc often occurs from jarring or vibrating a wire, like German silver, at a much lower temperature.

Such wires as nichrome and the nickel-copper group have a very low temperature co-efficient. This means that their resistance is but slightly affected by change of temperature. When used in heaters and connected across a circuit of a fixed voltage the same amount of heat will be given out regardless of whether the air surrounding the heater is hot or cold. On the other hand, iron wire has a larger temperature co-efficient which means that its resistance rapidly increases with rise in temperature. An iron wire having a resistance of 100 ohms at the temperature of 32 deg. F., has a resistance of 200 ohms at 347 deg. F. The result is that an electric heater equipment in which iron wire is used is in a certain sense automatic.

If cold air enters the heater, demanding a larger heating effect, the high temperature co-efficient causes a larger flow of current to meet the demand. Anything which prevents the escape of heat acts to throttle the flow of current and reduce the rate at which heat is generated. This feature is of value especially where heaters are used on lines on which there is a wide variation in voltage. The high temperature co-efficient causes a more even heating effect as cars move over the lines under this varying voltage.

The amount of current required for heating cars and the cost of same will be a matter of interest.

We have equipped several thousand surface cars in the city of Chicago and have made quite a few observations upon them. The cars are not all alike but there are several thousand cars of exactly the same kind having bodies 32 feet 5 inches in length over corner posts and seating 42 passengers. These cars are all equipped with fourteen of our cross seat heaters and four panel heaters with a maximum rating of 400 watts each at 500 volts and, therefore, having a maximum current consumption of 7,200 watts. The voltage at times runs up to 535 volts, so that the maximum amount of heat will be somewhat increased. At this voltage the consumption runs up to about 7,330 watts. This car has a cubical contents of 1,932 cubic feet or 3.8 watts per cubic foot. Storm sash are used on all cars and we recommend that all cars be so equipped. The same amount of heat produces a rise of temperature, thirty-four per cent. higher where storm sash are used than where storm sash are

not used. These cars conform to the requirements of the city of Chicago which requires the cars to be heated to a temperature of 50 deg. when the outside temperature is 10 deg. F. above zero or higher and to 45 deg. F. when the outside temperature is below 10 deg. F.

On February 12, 1913, at 10:00 a. m., the outside temperature was 5 deg. above zero and we took at random, ten cars and the stationary thermometers in these cars registered temperatures as given below:—

Car No.	Paye cars Type.	Net Cubic Contents.	Car Temp.	Outside Temp.	Consumption of heaters.
713	steel—monitor deck	1932 cu. ft.	42°	5°F	7330 watts
135	wood—monitor deck	1932 cu. ft.	53°	5°F	7330 watts
895	wood—monitor deck	1788 cu. ft.	58°	5°F	7330 watts
923	wood—monitor deck	1788 cu. ft.	56°	5°F	7330 watts
870	wood—monitor deck	1788 cu. ft.	53°	5°F	7330 watts
875	wood—monitor deck	1788 cu. ft.	60°	5°F	7330 watts
1583	wood—arch deck	1810 cu. ft.	58°	5°F	7330 watts
1577	wood—arch deck	1810 cu. ft.	52°	5°F	7330 watts
1601	wood—arch deck	1810 cu. ft.	50°	5°F	7330 watts
1699	wood—arch deck	1810 cu. ft.	59°	5°F	7330 watts

It will be noted that car No. 713 was a steel car. The nine wooden cars gave a rise of temperature on the average of 50.44 deg. F. above the outside air. The steel car gave a rise of 37 deg. F., with the same amount of heat. This would indicate that the steel car should have about 36 per cent. more heat than the wooden car for the same rise of temperature.

The costs of electric heating depend upon the cost of current. It still remains an open question as to just what items should be charged to electric heating. I am inclined to think that it would be but fair for a company considering the advisability of introducing electric heaters in their cars to consider, not the total proportionate cost of current consumed, but rather the additional cost of generating the current to supply the heaters. In other words, it would not seem just to charge to electric heating such power house expenses as would continue the same providing the electric heaters are not used. It would be proper to charge only the cost of additional current. This cost is covered practically by the cost of the additional coal burned on account of the heater load. With coal at $2.00 per ton this cost amounts to about .29 of a cent per K. W. H.

The cars in Chicago are provided with a maximum of 7,330 watts or 7.33 K.W., so that each hour 7.33 K.W.H., of current would be

consumed. At .29 of a cent per K.W.H., 7.33 K.W. would cost 2.12 cents per hour. This is the maximum current for the coldest weather. The average current for the winter season in Chicago is about 3½ K.W., under hand control or about 2.8 K.W., under thermostat control. Many railroads, on the other hand, buy current and pay prices varying from .75 cents, .84 cents, 1 cent and 1¼ cents per K.W.H., for current. If under thermostat control and current costs 1 cent per K.W.H., the average cost of heating a car for the winter months will be 2.8 cents per hour. This should be multiplied by the number of hours per day that the car is in operation to obtain the daily cost. It is to be noted that some railroads purchase power on the peak load basis. That is to say, the consumption of the day is taken to be at the rate of maximum consumption or at the peak of the daily load which comes a few minutes before 6 p. m. When a railroad operates under this kind of contract it is entitled to use current up to the maximum without extra cost. This means that there is no extra cost of current unless it adds to the peak of the load. It is, however, the peculiarity of thermostatic regulation, that the period of peak load is the period of crowded street cars and on account of the extra heat from the bodies of passengers the thermostats tend to cut current off of the heating system for the greater part of the time. Under these circumstances it is difficult to determine just what the cost would be. It would appear, however, to be very small.

The application of electric heaters to the heating and ventilation of houses is one of the problems of the near future. The high cost of current furnished by electric companies makes the use of electric heaters for house heating prohibitive. In some parts of the far West, however, the cheap current from water power and the high cost of coal brings the two sources of heat more nearly to a competitive basis. We look for radical developments in this field within a few years.

CCCXLIX.

NOTES ON SUGGESTED FORMULA FOR CALCULATING THE NECESSARY AMOUNT OF RADIATION FOR HEATING ROOMS BY HOT WATER, PARTICULARLY APPLICABLE TO THE HEATING OF ALL-GAS KITCHENS, BY HOT WATER FROM A FURNACE COIL OR A WATER HEATER.*

JAMES A. DONNELLY, MEMBER

It is not usual to figure the amount of radiation required during average conditions of outside winter weather, but to figure the radiation necessary for the lowest outside temperature. The formula suggested should be modified in several particulars.

Under C, it should be stated that the temperature of an unheated space under a room is usually taken as 30 deg., and not as the lowest outside temperature. The co-efficient for the floor under these conditions is usually considered as 0.1, rather than 0.3.

Under D, the temperature of an unheated space over a room is usually considered 30 deg., the same as under C.

Under F, the constant 0.04 provides for two changes of air per hour. This is thought to be rather high, 0.02 providing for one change of air per hour is usually considered sufficient for good construction. If the building is of poor construction it may be necessary to provide for two changes of air, or to increase the co-efficient for north or west exposure.

Under I, it is not thought necessary to increase the northern exposure by 20 per cent.; an increase of 10 per cent. is usually con-

*This paper was prepared in response to an inquiry from the American Gas Institute, through George S. Barrows, of their committee on Utilization of Gas Appliances. They submitted a formula for calculating radiation for kitchens in which the cooking would be done entirely by gas and the formula in this paper is recommended as a better one to meet the conditions.

sidered sufficient. If the room is exposed to the east it is not thought necessary to increase the heat loss, at least not on the eastern coast of the United States. The allowance for eastern and western exposures might have to be modified for different sections of the country.

Under J, if the water in the radiators is assumed to be 170 deg., it is thought that the proper co-efficient of transmission will be 150 rather than 170 B.t.u. per sq. ft. for 100 deg., difference between the radiator and the room. This is based on a co-efficient of 1.67 (for 2-col. 38-inch radiators) per sq. ft. per degree difference when the temperature difference is the standard 150 deg. This results in the usual co-efficient of 250 B.t.u. per sq. ft. per hour. Assuming that this co-efficient of 1.67 for 150 deg. is reduced 2 per cent. for each 10 deg. decrease in difference in temperature from standard conditions, with 100 deg. difference, it would be reduced 10 per cent. and would thus become 1.5. Multiplied by 100 deg. difference gives the co-efficient mentioned, 150.

While it is desirable to have the formula as simple as possible, there are other factors which have not been taken into consideration, such as different qualities of frame construction, different thicknesses of brick wall, as well as sky-lights, etc. Some data should also be available concerning the co-efficients of different heights and widths of radiators, pipe coils, wall radiators, etc.

TO OBTAIN THE SQUARE FEET OF RADIATION REQUIRED FOR HOT WATER HEATING.

Add together the following:

A. Square feet of window surface (if storm windows are used multiply by 0.5).

B. Multiply 0.3 by the square feet of the exposed walls (exclusive of windows or doors, except where there is a storm door, or the door opens to an enclosed porch).

C. Multiply 0.1 by the sq. ft. of floor, if the room is over an unheated space, the temperature of which is taken as 30 deg.

D. Multiply 0.3 by the sq. ft. of the ceiling if the room is under an unheated space, the temperature of which is taken as 30 deg.

E. Ordinary outside doors, on account of their leakage and because of the fact that they usually have a considerable proportion of glass, are considered as glass surface. Where there is a double door or an enclosed porch they are considered the same as wall surface.

F. Multiply 0.02 by the contents of the room in cubic feet. (This allows for one change of air per hour, by leakage.)

G. Sum of A, B, E and F.

H-1. Multiply this sum, G, by the difference between the lowest outside temperature and the desired room temperature, in degrees Fahrenheit.

H-2. Take the sum of C and D and multiply it by the difference between 30 deg. and the desired room temperature, in degrees Fahrenheit.

I. Add together H-1 and H-2.

J. Increase this (I) by 10 per cent. if the room is exposed to the north or west.

K. This product J, divided by 150 will give the number of sq. ft. of radiation required.

FIRST EXAMPLE

Assume a kitchen ell, the room being 12 ft. square and 8 ft. high with unheated space both below and above, on the north side of the house so that there is one wall exposed to the north and one wall exposed to both east and west. There is one window on each side of two sides, each window being 6 ft. high by 3 ft. wide and one door 7 ft. high by 2½ ft. wide. The building is in a part of the country where the lowest temperature is 10 deg. F., and it is desired to keep the room at 65 deg. during the time of greatest cold.

A. Square feet of window surface—2x3x6 equals 36 B.t.u.

B. 0.3 by the square feet of exposed wall surface (subtract surface of windows and doors 0.3 by (3x12x8)—(2x6x3) plus (7x2.5) equals 73.3.

C. .1 multiplied by sq. ft. of floor—12x12 equals 14.4.

D. .3 multiplied by sq. ft. of ceiling 12x12 equals 43.2.

E. Square feet of door surface—7x2.5 equals 17.5.

F. .02x12x12x8 equals 23.0.

G. Sum of A, B, E and F equals 149.8.

H-1. Multiply this sum by 75 (difference in temperature between 10 deg. F and 65 deg. F.) equals 10,235 B.t.u.

H-2. The sum of C and D, 59.6, multiplied by 35 (difference in temperature between 65 deg., F. and 30 deg. F. 2,051 B.t.u.

I. The sum of H-1 and H-2 equals 12,286 B.t.u.

J. Increase this by 10 per cent. for north and west exposure 13,514 B.t.u.

K. Divide this product by 150, equals 90 sq. ft. radiation.

SECOND EXAMPLE

Assume a kitchen ell the same as in example number one, with the exception that the spaces above and below are heated to the same temperature as the room.

The heat loss will then be a total of A, B, E and F, as in the first example. This will be a total of 149.8 B.t.u. for each degree difference.

This multiplied by the 75 deg. difference will give a total loss of 10,235 B.t.u.

Increasing this by 10 per cent. for north and west exposure gives an extra loss of 1,023 B.t.u. which added to 10,235 gives 11,258 B.t.u. as the total.

K. Dividing this by 150 gives the square feet of radiation, 75 sq. ft.

DISCUSSION

Mr. Jas. A. Donnelly: I might say that this variation of 2 per cent. for each 10 degrees above was developed by Mr. C. A. Fuller of our Society in some of his work in New York. It seems to agree very closely with the coefficient as given by Professor Carpenter.

Mr. Geo. S. Barrows: This question of the proper amount of radiation for houses, particularly for kitchens, has come up because we, of the gas companies are very anxious to put in what are called all-gas kitchens; that is, to equip kitchens so that there shall be no coal range; and it is entirely practicable to do this if the kitchen is heated. But if the kitchen is only heated by means of the ordinary gas range which is a very inefficient heater necessarily because it is constructed so as to conserve as much heat as possible, the gas bills will run up pretty rapidly.

Manufactured gas for heating at the present prices will not compete with coal unless one is willing to pay something for the cleanliness and convenience. I am speaking now of manufactured gas at prices down as low as 80c, compared with hard coal at around $6 or $6.50 a ton. There are being designed at the present time a number of gas heaters for use in the kitchen such as a gas heated steam radiator; but in all probability the most desirable means of heating the kitchen is from a boiler fired by coal placed in the cellar, and the heat in the kitchen

obtained by radiation from a suitable radiator placed in the kitchen and in series with the ordinary domestic supply of hot water.

The question of the proper formula for determining radiation was brought up because canvassers who have had no experience in estimating hot water radiation must be able to talk to the householders and tell them about how much radiation is needed and what size boiler should be used. That question I think has been pretty thoroughly answered by Mr. Donnelly, and I am very glad indeed that he has given such an interpretation to the formula. I think we will probably be able to make very good use of it and the data which I am sure will be available before many seasons go by, we will be very glad to submit it to you if you care to have it.

We have considered several different formulas, a number of which possibly do not pay quite so much attention to the exposure of the room as does the formula that Mr. Donnelly has given. We feel that we should pay some attention to it, because it is very desirable that the kitchen should have all the heat that is necessary. We consider the average low temperature as well as the lowest temperature, because in some places the consumer will wish to pay less for the installation putting in a small amount of radiation and a smaller boiler, and when it is necessary to get additional heat during the coldest weather, then run the gas range and heat from the oven. That is not the most desirable method, but in some cases the local conditions may be such that it will be more desirable to do so.

In all cases we are going to suggest that they put in radiation sufficient to take care of the coldest weather.

We are going to suggest, and would like some expression of opinion from you, that they put in a heater or boiler which will be amply large. From some of our investigations we have found that the smaller heaters require constant attention in order to keep the fire going properly. That of course is due to the chilling effect of the water on the fire. Also the small heaters all have shaking or drop grates which for the ordinary woman who is running a kitchen are difficult to shake down properly. She will not shake the grate enough, or else drop the whole fire in the ash chamber. It has seemed to us that probably a duplex or triplex rocking grate would probably be much more desirable. That would mean a somewhat larger boiler.

CCCL.

PROGRESS IN GAS HEATING SCIENCE

O. J. KUENHOLD

The scientific design of gas warm air furnaces and hot water boilers is one of growing importance.

Each year sees more buildings heated with both natural and artificial gas.

At the present time heating with natural gas is undergoing remarkably rapid extension, but within the next ten to twenty years heating with manufactured gas will unquestionably make equally rapid strides.

Natural gas has the great advantage of low cost as compared to coal gas. It is used extensively in the states of New York, Pennsylvania, Ohio, Indiana, West Virginia, Kentucky, Oklahoma, Kansas, Arkansas, Missouri, California, and others, as well as the provinces of Ontario and Alberta in Canada.

In many cases the gas is conveyed by means of pipe lines to cities several hundred miles distant from the gas fields.

The permanence of these gas fields has been the subject of much attention. The generally accepted opinion is that the best of the present fields will probably last at least another generation and probably longer. New fields are also being discovered and developed.

It is to producer gas, however, to which gas engineers look for the greatest possibilities in relation to heating buildings. Producer gas can be made much cheaper than illuminating gas.

When illuminating gas is distilled from a ton of coal there is three-quarters of a ton of coke left. When producer gas is generated from coal there is nothing left but ashes. The cheapest grades of coal may be used, so poor in quality that it hardly pays to ship it from the mines.

The logical development in the gas industry is to place the gas producing plants at the coal mines, generate the gas there

and transport it to distant cities. This would eliminate the quite considerable expense of sorting, screening, handling, storing, transporting, etc., and attending losses, which are necessary under the methods at present in vogue.

Indeed some gas producer engineers go so far as to say that hoisting the coal from the mine to the surface is unnecessary expense and that the gas producer should be placed in the mine and generate the gas there.

Referring again to illuminating gas as now made in cities, as a fuel for heating buildings. There are a number of facts pointing out the probable future development in this direction that are food for thought.

City gas has been steadily dropping in price during the past twenty years, while the price of coal has with equal steadiness advanced and will most surely continue to do so.

Electric illumination is making such inroads into gas sales that the gas companies must develop other fields than gas illumination, in order to dispose of their output.

Many gas companies are offering special rates, where gas is used for heating purposes and are finding it a profitable venture. This move is spreading rapidly. A notable example is—St. Louis where about two hundred buildings are heated by manufactured gas.

People are demanding comfort, cleanliness and convenience in their homes, and many are willing to pay an increased amount for gas fuel to eliminate coal and its attending evils from their residences.

The damage done by coal smoke in cities is being realized and initial steps are being taken to prevent it. The United States Government is making extensive investigations upon this subject. As an illustration of this trend—New York City has an ordinance permitting only anthracite coal to be used.

These few facts show how the price of heating with coal as compared to manufactured gas is approaching closer and closer

In many cases circumstances make even expensive coal gas so much more desirable than coal as a fuel, that coal is out of consideration.

One example of the above is in *private garages*. These must be heated to prevent the automobile radiator from freezing; make starting the engine easy; and for many other reasons. The method of heating must be rapid, convenient, clean, com-

pact, and last, but by no means least, the heater must be safe when gasoline fumes occur. Gas heat offers the only solution

In some sections of the country such as southern California, the weather is warm during the day but quite chilly at night. To heat with coal demands building a fire every morning. In mild weather coal heating appliances are difficult to control and are very inefficient while gas appliances are highly efficient in comparison. Under circumstances such as these, gas furnaces or boilers represent a convenient and economical solution.

In comparing the efficiencies of gas furnaces or boilers to those of coal furnaces or boilers, there is one point which should be noted.

Every coal heater has its maximum efficiency at a certain rate of combustion. When this rate is exceeded the efficiency drops. Also when the rate of combustion is less the efficiency drops, because of decreased temperature in the combustion chamber.

In gas furnaces or boilers wherein the air supplied for combustion is regulated separately to each burner as described hereinafter, the efficiency increases and the lower the rate of gas combustion, the higher the efficiency. With chimneys of good natural draft and well laid out heat distribution an efficiency of close to 100 per cent. is at times attained. Now this is a very important factor in determining the comparative fuel bills.

In a climate like Cleveland, for instance, the average temperature during the severe months is 38 degrees. The house temperature is therefore raised on an average of 32 degrees during 2/3 of the day and 22 degrees during 1/3 of the day. The average rate of combustion of fuel is therefore low. This results in lower average efficiency for coal furnaces and higher average efficiency for gas furnaces than is shown by laboratory tests, as same are usually made.

Besides the above there is another factor which plays an important part:—In coal furnaces or boilers the skill of the operator has much more influence than in gas heaters, so that the laboratory efficiencies of coal heaters are further reduced by what may be called a "factor of foolishness."

For these reasons, in estimating gas bills on proposed replacements of coal heaters, the writer submits the following comparative percentages of efficiency, as in his opinion giving as accurate results as may be expected under the many varied conditions which influence the actual results.

With coal at $5.00 per ton about six million heat units are obtained for a dollar. With natural gas at 30 cents per thousand cubic feet only about three and one-third million heat units are obtained for a dollar. In order for natural gas to compete with coal as a fuel it is necessary to obtain a much higher efficiency. Since in using gas all the factors making for higher efficiency are much easier to obtain natural gas furnaces or boilers properly designed can be operated at about the same price as coal costing $4.50 to $5 per ton, and about 30 per cent. cheaper than anthracite coal at $7 per ton.

The efficiency of a coal furnace or boiler under the usual conditions probably averages less than 50 per cent. for the entire winter, while a good gas furnace should average close to 90 per cent.

Experience with several hundred cases where gas furnaces were installed in place of coal furnaces, and the fuel bills compared, indicates that the rates of the efficiencies of gas and coal furnaces must be quite close to the above.

This gives us a basis which may be used in estimating the probable cost of heating with gas as compared to coal, provided that we know what the coal bills have been for the house considered, the heat unit value of the gas, and the cost of both the coal and the gas.

To illustrate this assume that for a certain house the coal used during an average winter amounted to 10 tons at $8.00 per ton probably containing 14,500 heat units per pound. At an assumed average furnace efficiency of 50 per cent., which is high, this would amount to one hundred and forty-five million heat units put to use in order to heat the building all winter.

Comparing this with manufactured gas of 600 heat units per cubic foot at a special rate of 60 cents per thousand cubic feet and taking as our basis 90 per cent. gas furnace efficiency, the same house would require 270 thousand cubic feet of gas, which at 60 cents per thousand would cost $162, as compared with $80 for coal, considering fuel cost only.

But in order to make an accurate comparison there are other items to be considered. A complete comparison would be about as follows:

COST PER YEAR OF HEATING WITH GAS.

Fuel used $162.00

COST PER YEAR OF HEATING WITH COAL.

Fuel used	80.00
Kindlings	2.00
Hauling ashes	5.00
Damage to house and furnishings by coal and ash dust	30.00
Repairs and cleaning furnace	10.00
Attending labor and inconvenience (seven months at $5.00 per month)	35.00
TOTAL COST	$162.00

It is assumed in the above that the gas furnace is under automatic control.

In order to heat with gas at the high efficiency necessary to compete with coal, the furnace or boiler must be designed especially for gas. In fact we should go even further than that, we should design it for the *kind* of gas to be used, just the same as a coal furnace or boiler should be designed for the *kind* of *coal* to be used.

Experience in replacing coal furnaces using gas fuel, by furnaces designed especially for gas, shows a saving averaging not less than 33 per cent. and ranging from 20 to 70 per cent.

By examining the most successful gas furnaces and boilers it will be noted that a sort of a school of design quite different from coal furnaces and boilers has been developed. This probably is in accordance with the laws of "natural selection" and "survival of the fittest" maintaining in engineering practice. It is another verification of the contention of the writer that gas furnaces should be used for gas and coal furnaces for coal.

In approaching the problem of gas heater design it should be borne in mind that two distinct functions are required of the appliance. *The first function is* the generation of heat from gas. *The second function is* the transmission of this heat to the heat conveying medium. By heat conveying medium is meant the *air* in a warm air furnace, or the water or steam in a hot water or steam boiler.

It is of vital importance that the first of these functions, i.e., the generation of the heat, is entirely completed before the transmission of the heat is begun. Both of these functions cannot be efficiently performed at the same time.

Unless this most essential requirement is fulfilled perfect combustion of the gas is impossible.

Let us consider these two functions one at a time, taking up first the generation of the heat, or in other words, the combustion of the gas.

We will not look into the details of burner and mixer design, but consider only the essential requirements for perfect combustion of which there are only three, but these three are as essential to complete combustion as length, breadth and height are to solid geometry.

The first is—Proper proportion of air and gas.

Second—Thorough intermixture of air and gas.

Third—A high enough temperature to make a complete chemical union of the oxygen in the air and the hydrocarbons of the gas possible.

Unless all three of these conditions are fulfilled, complete combustion and therefore the generation of every possible unit of heat cannot be achieved.

The usual procedure in constructing gas heating appliances is to install a burner, leaving the proper air supply to chance and making no effort to maintain a high enough temperature in the combustion chamber.

A burner or group of burners alone applied to a gas furnace, cannot give the best possible results. A complete system of combustion is necessary.

The writer has developed what he calls the *SCIENTIFIC COMBUSTION SYSTEM* and this will serve to illustrate the principles herein set forth.

In this system two or more oblong burners are arranged side by side. Above them is a combustion chamber, insulated on all sides to prevent appreciable loss of heat. Between the burners are cast iron partition plates extending down to the floor plate about 10 inches below the top of the burners.

Each burner therefore is in a separate compartment.

At the rear of each compartment is a rectangular opening having a shutter pivoted near the center. The air required for combustion is admitted through this opening. The shutter is connected by means of a rod to a little lever underneath the gas valve in front of the heater in such a way that when the gas is turned on to any particular burner, the air supply shutter of that burner compartment is opened in proportion to the opening of the gas valve.

By this arrangement if one burner is turned on full it will receive the full air supply. If another burner is turned on part way then the air shutter for that burner compartment will be

opened only part way. Each burner will always receive only the amount of air required.

In order to illustrate the advantage of this arrangement compare it with any furnace not having it. If in the latter in mild weather one burner is turned on this will naturally induce a draft. The draft will draw air through the heater at those burners not being used and this air not being used absorbs a considerable proportion of the heat generated by the burners in use, cools the inner surfaces of the furnace or boiler and carries this heat up the chimney.

In the SCIENTIFIC SYSTEM if one burner is turned on, this burner only receives just the amount of air needed and no surplus passes through the heater.

The second requirement mentioned, referring to a thorough intermixture of the air and gas is largely a matter of proper proportion of the burner and mixer. The stream of mixed air and gas is broken up into a number of jets. Each jet should issue from a raised stool or nozzle, all so arranged that air will be supplied to each separate jet all around.

The third essential is that there should be a sufficiently high temperature in the combustion chamber to make perfect combustion possible. It is this requirement that is so often violated in many gas boilers and furnaces upon the market.

In most gas boilers the bottoms of the hollow water sections are extended downward into the flame.

At first thought one would regard this as a highly desirable arrangement. But let us stop and think a moment what then happens.

The bottom of the water section has an average temperature in a hot water boiler of 150 degrees. The tip of a gas flame has a temperature of about 3,000 degrees. The difference in temperatures is 2,850 degrees.

The cast iron has a chilling influence upon the flame almost thirty times as great as a piece of ice upon the human body.

What actually takes place is this:—Whenever the flame comes close to the casting its temperature is reduced below the ignition point and that part of the flame is extinguished. It is in fact a chemical impossibility for the flame to come into actual contact with any surface the temperature of which is lower than the ignition temperature of the flame.

There is also another thin zone around the water section in which while the temperature of the flame is reduced it still permits the gas to be partly consumed to carbon monoxide, a deadly poisonous gas. It is this gas which causes the peculiar pungent odor which may be noticed in the flue gases where a gas flame is chilled by contact with water coils or castings.

The proper course to pursue is never to permit a gas flame to come into contact with any surface cooler than itself, if efficiency is the prime object to be attained. If the necessity of this principle were more fully realized, heating with gas would be more popular.

The main idea is this:—

First get complete combustion. When combustion is completed, but not until then, begin transmitting the heat into the air, water or steam as the case may be.

The cases in which exception may be made to the above is where speed is of prime importance, such as in instantaneous water heaters, or in cases where it is not practical to encase the flame so as to prevent the escape of heat.

Now having disposed of the first function of a gas furnace or boiler, we may consider the second which is to transmit the heat into the circulating medium.

The end aimed at in this is to extract as much heat as possible from the products of combustion, allowing only enough heat to remain in them to create a proper draft.

The burnt gases in passing through the furnace should be retarded as much as possible, but at the same time must travel fast enough so that they leave the combustion chamber as fast as generated, otherwise the flame may be partially smothered.

The draft may be retarded to advantage, much more than in a coal furnace.

A sufficient heat transmitting surface is necessary, however. It should be remembered that baffle arrangements, choked off dampers, etc., cannot be made a substitute for heat transmitting surface and proper interior circulation.

The length of travel of combustion products must be much greater in proportion to the cross sectional area, than is the practice in coal furnaces and the flue passages should be considerably smaller to obtain best results.

The vent pipe should preferably be attached at a low point. Hot gases rise, and cooled gases settle down. Let them settle

down in the interior of the heater first, then carry them to the chimney.

And finally—the direction of travel of the burned gases and of the air or water should be in opposite directions. This the writer calls *the principle of opposed circulation,* and it is of great importance, although not used very much in furnace and boiler design.

To illustrate this principle let us examine the average gas boiler. The water enters at the bottom and leaves at the top. The products of combustion also enter the heating space at the bottom and leave at the top. Both travel in the same direction. This does not render the highest efficiency. The air or water should travel in opposed directions. In other words, the exhaust gases should leave the heater at the part where the cold air or water comes in, that is, at the part of the heater where they can be cooled to the lowest possible temperature before going to the chimney.

The incoming water or air should travel toward the hottest part of the heater and just before it leaves is exposed to the hottest gases as they leave the combustion chamber.

With ample heating surface and the observance of the above principles flue gas temperatures as low as 100 to 120 degrees can be obtained and an efficiency of close to 90 per cent.

Experience also shows that it would be safe to guarantee that the furnace or hot water boiler shall never exhaust the gases to the chimney as high as boiling temperature.

In hot water boilers the vent pipe to the chimney will always be at a lower temperature than the outgoing water.

Another desirable essential of high grade design may be mentioned. The air or water passing through the furnace or boiler should not be baffled or retarded any more than is absolutely necessary, so that it can flow through the heater freely and have the strongest and most rapid possible circulation. The quicker that the circulating medium flows through the heater the more heat will be carried away.

By inspecting some warm air heating plants one notices that extreme precautions are taken to provide free and easy flow of the air through the leads, but in the furnace the air is baffled in every conceivable way. This is not consistent.

In some sections of the country gas furnaces are not popular because the gas pressure is unreliable in winter. In such cases

there are plenty of reliable auxiliary furnaces upon the market which can be attached to the side of a coal furnace so that the gas may be used with efficiency, but not as high as where the gas furnace is installed in place of a coal furnace.

All gas furnaces or boilers should preferably have arrangements for the temporary use of coal in case of emergency.

From the foregoing article it will appear evident that it is extremely unlikely that a furnace or boiler can be designed which is highly efficient both with coal and gas fuel. The two problems are so different in many ways, that the furnace must either be primarily a good coal furnace, a good gas furnace, or else a compromise between the two.

Where the highest efficiency is demanded as in artificial gas territory, hot water systems and vacuum systems, in which about 8 inches of vacuum may be maintained upon the system at the boiler, give considerably better economy than low pressure steam systems, in the experience of the writer.

In closing he invites criticisms or discussion upon the statements in this article.

DISCUSSION

The discussion of this paper was included in the discussion of the topic, "To what extent can manufactured gas be utilized economically in heating?"

Mr. R. P. Bolton: "To what extent can manufactured gas be utilized economically in heating?" I have recently completed a prolonged investigation which throws considerable light on this subject, and affords evidence that the use of gas is economically practicable in house heating work, where it will displace labor and fuel over quite a substantial portion of the heating season. The interesting facts which the observation established are, first, that a very small use is made of a heating plant during the latter part of the heating season in New York City, and that this condition is accompanied by an excessively costly steam production during such moderate periods of usage.

I hope to be able to present the details of these observations with another series to be extended over the first part of the ensuing heating season, in a paper at the annual convention of our Society in January.

The building in which the observations were conducted is a seven story business building heated by low pressure steam

raised in an Acme heating boiler and supplying about 1,600 square feet of direct radiation. The basement and first floor are heated by an indirect system. The operation of the plant during the period of observation which commenced on the 28th of February, was carefully watched, and all condensation from the radiators was measured by a meter which was calibrated on several occasions; all coal was weighed out and also the ashes, as removed.

The coal which was used is an egg anthracite of excellent quality, costing \$6.50 per ton of 2,000 pounds. The labor consists of one man who was paid at the rate of \$10 per week.

The average evaporation per pound of this fuel from and at 212 degrees fell from an average of about 8.3 pounds at the beginning of March, to a low point of 7/10 of one pound of water, per pound of coal, in the last week of the observations, ending May 16th. The percentage of unconsumed material removed from the ash pits rose from an average of about 17 per cent. to as high as 27 to 31 per cent., by weight.

The efficiency of the boiler declined from an average of 64 per cent. to 18½ per cent., and during the last week was only 5.5 per cent.

The actual cost of fuel during the last eight weeks of observations was \$93.13, and the cost of labor was \$80, making the total \$173.13. The comparative cost of city gas at 80 cents per thousand cubic feet for the same period, assuming an efficiency of evaporation of 90 per cent., would have been \$168.17, so that the use of gas during these eight weeks would have been nearly \$5 cheaper. During the last four weeks of the test, there would have been a direct saving of \$48.64 by the use of gas.

It would appear reasonable to assume that during the early period of the forthcoming heating season, very similar heating conditions would be in existence, and a comparison of the average temperatures of last year's heating season shows that the mean was almost exactly the same for the first eight weeks of the heating season, as for the last eight weeks of the heating season; the one being 49.8 degrees and the other 49 degrees.

The observations thus appear to demonstrate that even at the price of 80 cents per 1,000 cubic feet, manufactured gas could be utilized economically for house heating over a period of about sixteen weeks. The total heating season in New York City was thirty-two weeks, and therefore these conclusions apply to one-half of the total heating season.

Secretary Blackmore: I think that Mr. Bolton's paper comes as a revelation to most of you. I know it did to me, for while it had been my belief that at the beginning and end of the heating season gas could be used to some advantage, I had no idea that it could be used for one-fourth of a season at the same rate of economy as coal.

Mr. H. M. Hart: In reference to the discussion of Mr. Bolton which compares the cost of heating by gas with the cost of heating by coal, the Prentice Co. in Chicago at one time kept some very careful records of the cost of heating with gas at 50c per 1,000 cubic feet; we found that taking the whole season, the cost of heating by gas equalled the cost of heating with coal at $16 per ton; and a great many people after keeping the records themselves took out the gas, feeling that they would rather have the inconvenience and the dirt and the expense of shoveling coal and handling ashes if they could save money in the end. The gentleman that gave the paper on gas brought out a very interesting point to me that I think is worthy of some thought as applying not only to the burning of gas but of coal. He claims that the combustion chamber should be so constructed that the flame will not strike the cold parts of the boiler. I think that same rule should apply to house heating boilers and coal burning boilers. I think there is considerable loss in the combustion of coal on account of the water jacket extending down below the bed of the fire so that the gases in the flame cool when they strike the colder iron of the boiler and thus do not fully ignite. I think if the fire-box of a house heating boiler was thoroughly insulated with some good insulation, or if the water was kept above the bed of the fire, that a great deal more efficiency would be gotten from the fuel.

A Member: One thing that should be borne in mind generally is that if you take a coal burning furnace and put burners in it and then make a comparison of the cost of gas as compared with coal you will get a wrong perspective on it. The problem is different entirely. In a coal burning furnace the leading factor in the amount of combustion is the draft. In other words, the draft makes the fire, whereas the gas furnace is just exactly the reverse, the fire makes the draft; and there are a good many other points of difference between the two, so that the problem is entirely different, and the great trouble is that those who design gas furnaces try to design them along coal furnace lines, or they try to make what is called a combination furnace, which

has been defined by one disappointed customer as a combination between men who build furnaces and those who sell them. The combination furnace as used in Cleveland which has gas burners installed will as a general rule run almost 50 to 100 per cent. more in cost than coal at $4.50 or $5 a ton; whereas with a properly designed gas furnace you could get the same results that you can with coal. When compared with hard coal you can save 30 per cent. of the coal bill almost invariably. That would be in using 30c gas, 1,000 B.t.u. per cubic foot.

Mr. Jas. A. Donnelly: There is another perspective of this combination use of coal and gas that I have run across, and that is that when we get very severe cold weather the demand for natural gas usually increases until the pressure is so low that the supply becomes inadequate and then the man who has been using a gas furnace has to resort to coal. I have had some experience in some towns of that sort, where when cold weather comes around everybody has to resort to coal because they cannot get sufficient gas. With reference to Mr. Bolton's figures in New York, it would be interesting to have his comparison leaving out the cost of labor. Ten dollars per week for a man is of course pretty cheap; yet we have to consider that in most of our small installations the labor cost is negligible because the occupants of the house attend to firing themselves so there is nothing paid out on that account. Again, when a man is employed at say $10 a week unless it is a fairly large building he is not employed all of the time in taking care of the boiler and usually the occupants of the building find other things for him to do for which they would have to pay a considerable amount if he was not firing the boiler; so that a fair perspective of these costs would necessarily eliminate some of the labor cost.

Mr. H. M. Hart: You would also have to take into consideration that while you may save for eight weeks at the lowest or say eight weeks at each end of the season, I do not think that there is any interchangeable grates that can be readily installed without some expense for removing burners and putting in grates, which would add some expense if you were to switch in the middle of the year.

Chairman Allen: The thought occurs to me that perhaps it might be possible to improve the steam boiler burning coal so that we would have better efficiency in mild weather. There are two sides to the question.

Mr. Geo. H. Barrows: Taking up the question of house heating, it is a subject which of course we have studied very exhaustively both as applied to natural and manufactured gas. As I understand the figures given by Mr. Bolton they were given actually from coal and it was assumed that he could do with gas certain things. He took 90 per cent. as the efficiency of his gas heater. I think he will have some difficulty in getting 90 per cent. efficiency. It is necessary for the flue products to go off at a high temperature in order to get rid of them, unless a fan is installed. When burning gas perfectly there is no carbon monoxide, but the water vapor and carbondioxide in the products of combustion are considerably heavier than air and they will only rise so long as they are kept at such a high temperature that they will be lighter than air.

In the City of London where a large percentage of the heating is by open fire-places, in a two or three-story house gas is used very successfully, but in the houses of four or five stories they have a great deal of difficulty, simply due to the blanketing effect of the products of combustion which are cooled before they get out of the chimney. Particular attention must be paid to that. The products of combustion pass from the heating device at a fairly high temperature and therefore a relatively large amount is lost by convection.

The average circulating water heater in use to-day operates at an efficiency around 60 per cent. The average instantaneous heater will operate around 75 per cent. With a properly designed device it may be possible to get a somewhat higher ratio than that; but probably 80 per cent. is about as high as can be obtained.

In the spring and fall there is available a larger amount of gas heating than we realize, by means of auxiliary heat appliances placed next to the steam boiler, hot water heater or hot air furnace in the cellar. The main appliances being coal fired are allowed to go out say the middle of April, and the gas fired auxiliary plants started up and burned for a half hour or hour in the morning or evening when necessary, or even turned on for a day or two at a time during a cold spell. Where gas sells at $1 it is much more convenient and in all probability is about as cheap as coal for such short periods. In St. Louis it is said there are about 200 buildings heated by gas, the price of gas on a sliding scale being as low as 60c. Compared with cheap river coal the average cost of the gas heating is from two to

three times that of coal; accordingly gas heating is only considered desirable where cleanliness or convenience are objects. It is being used by all classes of consumers, both those to whom expense is no object and those to whom expense is a great object but at the same time cleanliness and convenience are greater.

When a woman has to do her own work, the fire makes her a certain amount of labor, and she is willing to pay more for fuel and less for laundry, and for that reason the use of gas for heating is being extended quite rapidly.

We feel in the gas associations that we must have the co-operation of such a Society as this; and it is a very great pleasure to me to be able to express to you here our appreciation that you have taken up this subject as you have; I trust that it may lead to a closer co-operation in the future.

Secretary Blackmore: Mr. Chairman, the question of combustion always comes up in a discussion on house heating boilers; and I feel that I could not let this opportunity go by without saying something. Mr. Hart raised the question of the value of water jacket fire pots. If you go back to the early days of boiler construction you will find that the majority of boilers were then made with the lower part of the fire box of fire brick. They were afterwards made with a cast iron water leg down to the grate. The question resolves itself wholly into that of the rate of combustion in the fire box, and the rate of combustion depends upon the draft supplied and the temperature in the fire-box. If ideal combustion takes place it is quite immaterial how much water surface you have around the fire, but the moment the combustion slows down to two or three pounds of coal per square foot of grate per hour, there is a difficulty in maintaining a temperature high enough to maintain good combustion when the fuel is in contact with a water jacket. A certain amount of the gases under such conditions will escape unconsumed up the chimney. The house heating boiler has to run between a wide range of combustion and the manufacturer has to make a boiler to suit average conditions and boilers under average conditions give good results with a water leg around the fire box. On a low rate of combustion the fire brick fire box would have some advantage but not sufficient to displace the water leg fire box.

Whether gas will become popular for use at the beginning and end of the season is very largely dependent on the develop-

ment of the art and the ability of engineers to take advantage of their opportunities. Householders are keenly on the lookout for something that will save work and dirt, we are going to a great deal of trouble in endeavoring to wash the dust from the air and the dirt that the average coal heater makes in the house does not improve the quality of the air the occupants breathe. When the householders begin to realize that the dust in the air is bad they will be apt to pay a little more for gas to prevent some of the dust. I hope Mr. Bolton will continue to watch this experiment and at a later date be able to present us with some definite data.

A Member: Has anyone here knowledge of a boiler that will work equally well with coal or gas? I do not think such a boiler ever has been made or ever will be made. I have had a little experience with natural gas and have put in boilers that have worked fine on coal, but when it got down to the gas proposition we had to take the boilers out so that they could go to burning coal again. As it looks to me, it requires a different type of boiler altogether for gas and coal.

Secretary Blackmore: In regard to a combination gas and coal boiler, I do not think any manufacturer who supplies boilers in a natural gas district would guarantee the same economy in both gas and coal in such a boiler. All through the natural gas territory in the winter the supply of natural gas falls below the requirements, hence the combination coal and gas boiler is put in as a measure of insurance that they can use coal at such times. We can hardly expect a combination of that nature to be equally good for both purposes. If it is good for one it will not be for the other. If you build your fire-box right for gas it will be too small to take care of coal.

Mr. Geo. S. Barrows: When I went into Kansas City I went to a city where natural gas was unknown. The gas company wanted to build up a business quickly, and I spent several months traveling around different parts of the country to find out the best practise in natural gas. We took the best and then improved a little bit on that. We, from the very first, told our consumers not to put in only natural gas furnaces. We were bringing the gas 125 miles. The pressure varied from 300 pounds in the field to 5 pounds in the city high pressure mains. The average consumption, we will say, of the ordinary residence would be at the rate of about 30 cubic feet per hour in mild weather.

That would go up to 180 or possibly 200 cubic feet during a cold snap, and this sudden demand simply meant that the people were using more gas than could possibly be supplied so that somebody had to go without gas as a fuel. There might be a break in the high pressure line, stopping for a short time all the supply and for these reasons we told everybody that they should always have some sort of solid fuel on hand to burn a furnace in which gas might be burned as well.

It took a great deal of experimenting to decide the best type of burner to give the best results and we only put them in after very carefully conducting tests to be sure that we were getting no CO. As we were getting very little excess oxygen and a relatively low flue temperature the efficiency of the burners was high. We were getting at our large power plant boilers of say 4,000 h.p., about 70 per cent., and that even with the leaky settings. With our domestic burners also we were undoubtedly getting a high efficiency. We know that with gas at 25c per 1,000 cubic feet compared with a very high grade of semi-anthracite coal at $7 a short ton, or anthracite coal at $9 per ton, that we were saving from 25 to 30 per cent., and in some cases more than that. But the average saving based on careful examination of the fuel bills for a period of several years, taking a very large number of consumers' bills for comparison, showed an average saving somewhere around 25 per cent.

We had a locomotive boiler on a temporary job used for supplying steam for air compressors. We burned our gas in a regenerative chamber using the radiant heat from the fire-brick before putting the products of combustion through the flues. The results were so satisfactory that we were led to think that probably we could use the same sort of fire-box chamber in the ordinary house heating appliance; and we put those fire-brick chambers into hot water and steam boilers as well as hot air furnaces and got the very best possible results. It was a little difficult for the consumer to take them out if he had to change quickly to coal; but as time went on we found ways of putting in the bricks so that they could be hauled out in perhaps one-half hour's time and in some cases less than that. It took perhaps two hours to build them up again when they wanted to change back from coal to gas.

The greatest care must be exercised to put in proper burners. I do not believe there is a furnace built which cannot be heated

just as well with gas as with coal, but you have to hunt around a great deal in some cases before you get the right burners.

Mr. O. J. Kuenhold: The Company I am with had about the same experience and made burner installations arranged in the same way. After installing them we watched the gas bills for the season. The results varied so much in the different installations that we decided to discontinue making them, and thereafter recommended regular gas furnaces wherever gas was to be used.

I believe that the failure in the cases mentioned was because of imperfect transmission of the heat to the air passing through the furnaces.

It should be remembered that there are always two steps to be accomplished: First, generation of the heat. Second, transmission of that heat. The first step, that is, the combustion of the gas may be made perfect, but coal furnaces are not always adapted for high efficiency in heat transmission. They may be efficient enough in this respect for coal, but not for gas.

In speaking of a furnace efficiency of 90 per cent. for gas furnaces, it might be explained that I regard as lost only the heat units going up the chimney in the shape of sensible heat, or as unburned gases. The radiation from the furnace into the basement, unless excessive, may be regarded as useful heat, for it helps to keep the basement and the floor above it warm.

Of course in power boilers the efficiency must be estimated differently. In that case all else except the heat delivered into the steam pipe is lost. We might call the former gross efficiency and the latter net efficiency. This difference may account for differences in the findings of various engineers in gas or coal furnace efficiency.

In regard to flue temperatures—we obtain temperature as low as 110 to 120 degrees under normal conditions in most all cases, on gas hot water boilers and warm air furnaces.

Mr. George D. Hoffman: I live in Los Angeles, where they burn oil almost altogether. Two years ago a concern came in there and introduced the Rector Gas Heater. I would like to ask Mr. Barrows if he has had any experience with or knows anything about that system of heating. They have a blast and draw the heat up through the radiator and then out through a pipe leading to the open air.

Mr. Geo. S. Barrows: The Rector system is a very interesting one. I do not know whether it has been developed to a perfectly successful point, or not. We have worked with Mr. Rector, that is, we have worked together as we work with other men having gas burning appliances. We have given him some suggestions and criticisms on his appliances. In his burner he takes in no secondary air to support combustion, but brings in a proper amount of primary air, not by forcing it, as is done in the ordinary air blast furnace, but by exhausting the products of combustion so that there is a vacuum created around his burner and the air is mechanically drawn into it as primary air. In that way he gets a greater efficiency than with the ordinary atmospheric burner. Just what it is I do not know.

The Rector system when applied to incandescent lighting will increase the efficiency from 30 candles per foot to 60 candles per foot or doubles the efficiency, and in all probability very nearly doubles the efficiency in the heating appliances.

The Rector system control is by the use of a thermostat placed in any desired location in the house or room. There is a valve in the gas pipe controlled by the exhaust pressure by means of a diaphragm and an electric fan to create the suction. When the room reaches the proper temperature (which is set on the thermostat in the ordinary way), the current is shut off from the fan. As soon as the fan stops the exhaust stops, and the gas valve controlled by the diaphragm is operated by means of a spring and shuts the valve so that the main gas burner is shut down. There is a pilot burner which is operated from a separate line and remains lighted. As soon as the room cools to the point which is set on the thermostat the current is turned on to the fan, which starts up the exhaust created by the fan causing a partial vacuum against the diaphragm which controls the gas valve, so that the main gas burner is turned on, and is lighted from the pilot. In that way the device is automatic.

Automatically controlled gas devices, however, are something which a good many of us gas men look upon with considerable doubt. In any gas burning device operated by means of a pilot flame the pilot flame may go out; so that we only like to see such devices go in where they will be under the supervision of the operator.

Mr. Rector is now developing a non-automatic type of radiator, that is, one in which the burner will be turned on manually; and lighted from the pilot, or by a match.

I understand a very large number of Rector heaters have been installed in California which has been the largest field of operations. Quite a number of them have now been installed in the southern states.

I believe that some of these Rector heaters have been installed in Toronto and Staten Island, N. Y., and the costs of operating I have been told, seem to compare very favorably with coal.

The condition under which a heater is used must always be given consideration. A gas burning appliance in a room which is intermittently heated will in all probability, even in a cold climate, with gas at a high rate, compete with coal, especially when the convenience of operation is taken into consideration. You have heat when you want it, and the instant you are through with it it can be shut off. It is not necessary to build up a fire. When you build up a coal fire and let it go down, its efficiency is very greatly decreased.

Chairman Allen: I do not understand that system, whether there is a steam radiator in each room. I do not understand where the fan was placed. Was it in the smoke flue?

Mr. Geo. S. Barrows: The fan is in the flue. There is a hot air radiator; which is built in the form of a steam or hot water radiator. The burner is in the center of the radiator and the products of combustion circulate up and down the flues. Cast iron is used because the temperature of the radiator in immediate proximity to the burner is very high, running up around 700 or 800 degrees I think—I do not know but what higher than that. A radiator is placed in each room—two or three radiators in each room if necessary. One fan, preferably in the basement of the house—although it can be anywhere, operates all the radiators. Leading from each radiator there is a piece of wrought iron gas pipe usually about 3 inches in diameter, as the exhaust pipe. The size of this increases as the number of radiators increases.

I do not know what the temperature of the flue from the radiator is. I think it is somewhere around 300 degrees. All those that I have ever seen have been exposed in the room, and were only put in office buildings or warehouses where the appearance didn't cut any figure at all, and where the flue pipe could be run outside of the partitions and the flues all run to one fan. In

our test in our laboratory we had only six radiators; but I believe in some business installations they have as high as twenty radiators.

Chairman Allen: Isn't it true that insurance companies look upon that radiator with considerable disfavor?

Mr. Geo. S. Barrows: The radiator cannot be set as close to a partition as an ordinary steam or hot water radiator because its temperature is so high and this high temperature of the radiator is one of the features to be considered. A guard might be put over the radiator.

CCCLI.

REDUCTION OR ELIMINATION OF NOISE ATTENDING THE OPERATION OF MECHANICAL VENTILATING MACHINERY

BY R. W. PRYOR, JR., MEMBER

As there does not seem to be any law which can be laid down to govern oneself on the installation of ventilating machinery, I will endeavor, in presenting this paper, to illustrate some different phases of the subject with the remedies used in these cases to correct the trouble. Below are given some experiences:

A 60-inch steel plate fan with overhung blast wheel was operating in a concreted basement. This basement was walled-in in a substantial manner, and entering into this basement where the fan was located, were some conduits. The fan was operating at a pressure of something over one ounce and there was no perceptible noise immediately in the vicinity of the fan. Yet, about a half a block away there was a decided rumble, which was traced to the operation of this fan. The fan was covered with 6 inches of hair felt: this helped to deaden the sound somewhat, but did not entirely correct it. It seemed as though the fan or something started a vibration of the air in this chamber, the sound of which was projected or carried through the conduit tubes to the location where the sound became audible. I believe this is one of the most elusive problems the engineer has to contend with.

Another instance was the case of two 24-inch motor driven propeller wheels, which were located in the rear of a Counting Room of a bank, discharging the air into a brick areaway. These fans made a howling noise, which might be termed windage. Due to the air rushing through the blades, the fact that they discharged into this brick areaway, aggravated the condition. These propeller wheels were changed to flat blade type, the speeds being approxi-

mately the same in either case, but the amount of air handled by the flat blade wheel is about 75 per cent. of that handled by the curved blade. The improvement was very noticeable and the noise practically eliminated. The speed of the first fan, and the velocity of the air through it, was too great for the size of the areaway and the sound evidently was the result of vibration due to the high velocity in a confined space.

In a certain building consisting of a hall approximately 48 x 54 x 17 feet high, with an open attic space above, there was located a 36-inch disc wheel with direct connected single phase motor running at 600 r.p.m. This fan had no immediate connection with any duct work, being mounted on a special steel support held firmly in the brick wall. This fan drawing on the attic space, effected its ventilation of the hall through openings leading from the hall into the attic space. The hum from this outfit was so objectionable that the apparatus could not be used. The location of this outfit was changed so that it did not pull its air through quite so great a distance, thereby changing the proportion of the cubical contents through which it was drawing to the volume of air handled. The outfit was supported in a similar manner as before, and to one of the same brick walls; the same material being used as far as possible to make the change, and the fan running in the new location gives the desired ventilation without the noise which was so objectionable. This seems to bear out the theory that we have to consider the question of sound produced by the vibration of the air independent of the sound produced by the friction of the air against the walls of the duct. I think this condition is further exemplified by the fact that sound travels approximately 61,000 feet a minute, which on ventilating systems, such as we have been considering, gives the velocity of sound anywhere from 60 to 100 times greater than that at which the air is traveling.

This resonator effect is one that there does not seem to be any way of anticipating or pre-determining, making it necessary to resort to a "cut and try" process.

I want to cite another instance where there was an installation, for ventilating an auditorium, of two 30-inch propeller wheels with direct connected one horse power motors, 600 r.p.m. direct current; the outfits being installed in the duct work, and bolted to a brick wall by means of lag screws and one-half-inch rubber washers. The ducts were provided with flexible canvas connections 8 inches long, so that there would be no metallic connection to conduct vibration, if the fan should produce any,—and on the

outlet side of these fans, where they discharged into a brick flue, they were provided with a galvanized iron sweep to turn the air without shock. These wheels were so noisy that it was impossible to run them over 400 r.p.m., at which speed they did not give enough air to properly ventilate the room in question. The noise at 600 r.p.m. was about like a planing mill exhauster running at 3-ounce pressure. Those of you who are familiar with this class of work, will appreciate what such a noise would amount to. After trying several remedies, the fans were pulled out, and there were installed in their place two 80-inch full housed fans, each belted to one horse power motors; the fans running at about 170 r.p.m. The same duct work throughout was used, and the volume of air delivered was slightly increased. The trouble was absolutely corrected. The new fans were placed slightly nearer to the auditorium than were the propeller wheels; but the motors were placed outside of the duct work; so, the combination which originally produced this noise was completely changed.

I cite another case on some small volume exhausters which were running at 1,200 r.p.m. with direct connected motors, and for which we substituted 40-inch steel plate belted fans at 480 r.p.m. In this case more air was handled than before with complete elimination of noise.

In these various illustrations, I would say that the disturbance in each case was caused by air vibrations rather than any mechanical defect. Mechanically these various outfits were above criticism.

There are some factors which are important, viz.: the number of turns or the revolutions of the fan wheel; and whether the motor is in the air travel or not. The swish or rushing noise due to the air passing through duct work at high velocities and being deflected around elbows.

Some motors more than others produce a magnetic hum, and if the motor is in the air current, this may prove objectionable. The spokes of a fan wheel turning up at a rapid rate, interfering as it does with the air current, gives a rushing sound to the air.

Methods of insulating and deadening units are of importance, and on small direct connected ventilating sets, I have used with success a cast iron unit bedplate containing the fan and motor. This bedplate being approximately 2 inches high and having sufficient weight in it to hold the outfit firmly without bolting. This bedplate is then mounted on about 2 inches of hair felt.

Appended hereto is a sketch—see Fig. 1—of foundation design which was used on a double 120-inch Conoidal Fan in a New York

hotel—the fan being located on the third floor of the building. This has given good satisfaction and is, to my mind, a good foundation.

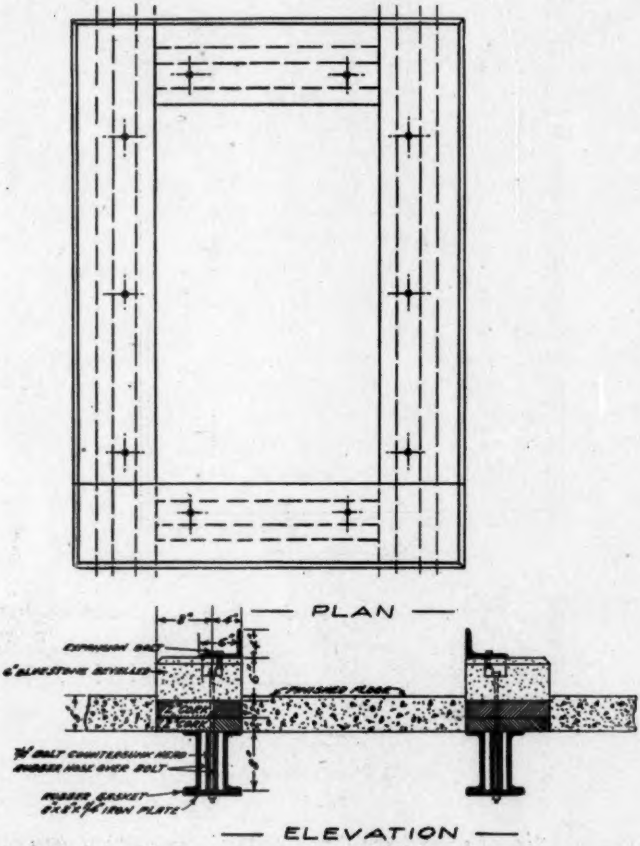


Fig. 1

Another form of setting for fans located on the upper floors of buildings, is to place the fan on an 8-inch monolith of concrete completely surrounding the concrete with 2 inches of cork, bottom and sides. See Fig. 2. This gives considerable weight to

base in the 8-inch monolith and absorbs any vibration, and the cork acts as the insulator.

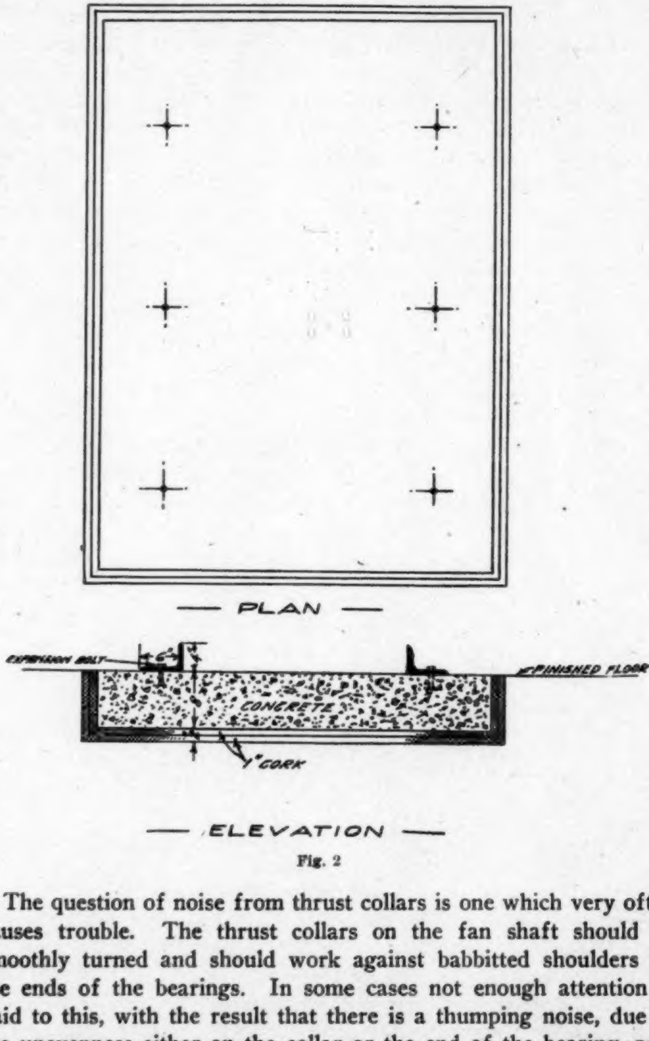


Fig. 2

The question of noise from thrust collars is one which very often causes trouble. The thrust collars on the fan shaft should be smoothly turned and should work against babbitted shoulders on the ends of the bearings. In some cases not enough attention is paid to this, with the result that there is a thumping noise, due to the unevenness either on the collar or the end of the bearing, particularly if the fan is a belted one and there is some inequality in the alignment of the belt.

The duct work is sometimes noisy due to the air traveling through it at considerable velocity, especially if the duct work has not been properly braced. Furthermore, at high velocities it has been necessary to increase the resistance of duct work at elbows, due to the fact that the elbows furnished, while being theoretically and practically good elbows for the conveying of air, were of such angle as to deflect the air, creating a slap on the opposite side. In some cases good elbows have, of necessity, had to be spoiled in order to correct this, and I am informed that some of the engineers have used 1-inch hair felt covered with canvas on the inside of the ducts at places such as these, to absorb the noises produced by the reflection of the air—and where these corrections have been made, it has been necessary to increase the speed of the fan in order to put up additional pressure to overcome the resistance.

DISCUSSION

Mr. H. M. Hart: Possibly I do not understand this sketch, Fig. 1. It looks to me as though the foundation bolts from the angle iron fastened to the fan are extended through the blue-stone through the cork and upright to the I-beam. I am wondering if that will really eliminate the vibration which is communicated to the I-beams. Possibly I do not get this sketch quite clearly, as it is rather a small sketch.

Mr. R. W. Pryor, Jr.: The fan is held to the blue-stone by lag screws (expansion bolts). The blue-stone is held fast to the I-beam with that long bolt, the head of which is countersunk in the blue-stone. Of course that is mounted on the cork.

Prof. John R. Allen: As far as the reduction of the vibration is concerned, my experience in putting rotating machinery in the upper floor of buildings, particularly where there is concrete construction is that the more rigidly you bolt or fasten machinery to the building structure the less vibration you will have.

I refer now to the question of vibration. I have had some experience with fans and motor generator sets where we had a great deal of trouble with vibration. In one particular case the motor generator set was set on a steel frame about two feet above the floor, and on that steel frame there were rubber buffers about an inch thick, and on top of that was the motor generator set. We had great difficulty with vibration. I took

the rubber out and filled the steel frame with concrete. I bolted the generator set down to the concrete and made it absolutely part of the building. After that we had no more trouble.

I was wondering in this case, Fig. 1 and 2, if you left out the cork and substituted concrete, whether you would not get better results. My own experience is that an elastic material in such places only tends to accentuate the vibration in many cases. One thing to be always avoided is an overhanging end which may come into synchronism with the rotating machinery itself.

President Lewis: That is very interesting if you have any trouble with noise. The experience seems to be that the modern monolithic construction is a good deal like a drum or a violin case, it is resonant and carries sound, while it cannot carry perceptible vibration.

Prof. John R. Allen: My remarks were limited to vibration. The question of noise is another problem. Where you want to reduce vibration that is by far the better practice. Of course it reduces itself down to the fundamental idea that there are certain unbalanced forces which if applied to a small weight give a large motion, but if applied to a very much larger body you get very much less motion and therefore less vibration.

Mr. H. M. Hart: Professor Allen's experience relates to vibration and not to noise. If you have noise which is not due to vibration of machinery, why, the fastening of the machinery direct to the building structure would certainly communicate the noise.

Mr. J. I. Lyle: I think Professor Allen would have gotten the same results with his motor generator set if he had used concrete and had insulated it from the building. It was the weight that absorbed the vibration. He put in a heavy block of concrete and tied it into the building. He was using the whole weight of the building. I think Mr. Pryor has guarded against that, and in most of these sketches he has put a weight in to absorb the vibration.

Mr. H. M. Hart: I do not want to do too much talking but must make exception to one statement in the paper. Mr. Pryor made a point of the vibration of the air, and in one case he substituted a centrifugal fan for a propeller fan, eliminating the noise. Now isn't it true that he was running his propeller fan at too high a peripheral velocity, and in changing the fan he ran it at a lower velocity and therefore reduced the vibration

of the air and then he had a different condition entirely. If the fan noise was due to the vibration of the air in the duct work, I do not think the centrifugal fan would have changed it at all, because it delivered more air through the same ducts; so that his two experiences do not seem to check up. In one case he changed the location of the propeller fan to reduce the noise; in the other case he changed to an entirely different outfit. In the first case where he changed the location of the propeller fan he tries to show that the noise was due to the vibration of the air traveling through the space to the fan, as I understand it; and in the second case by utilizing some surrounding conditions and changing the fan, it shows that maybe the conditions that he thought he had in the first place were not so, that the elimination of the noise by changing the fan might have been due to something else. I do not quite get it.

Mr. R. W. Pryor, Jr.: I will answer Prof. Allen first, by simply stating another experience that just occurred to me. On the top of the Hotel Kimball in Springfield, Mass., I had a 120-inch housed fan exhausting air at three-quarters of an ounce pressure. The engineer with whom I was associated on that job concluded that he would bolt it right to the arch of the roof which was of the usual construction of re-enforced concrete. The fan made a rumbling noise, that was objectionable to those sleeping below it, and I told him he had better put it on a separate slab of concrete. He did so and while it did not entirely correct the rumble, it was reduced to such an extent that it was not objectionable, at least there were no more complaints made. I do not know whether it was due to the absorbing of the vibration that Professor Allen referred to or not.

Mr. Tait: What was the thickness of the cork?

Mr. R. W. Pryor, Jr.: Two inches. The peripheral speed of the wheels was changed on those two installations. In one case we had a 36-inch propeller wheel making 600 r.p.m., which would give you a peripheral velocity of roughly speaking 5,400 feet per minute. They were 80-inch housed fans and had wheels in them approximately 5 feet in diameter. We were handling more air according to the tests.

Mr. H. M. Hart: In the instance given on page 2 of the 36-inch fan running at 600 r.p.m., you simply changed the location of the outfit and still maintained it at the same speed, didn't you?

Mr. R. W. Pryor, Jr.: Yes. That particular installation was in an open attic space. There was an ante-room in front of this

hall which opened also into this attic space. The wheel was located so that it was drawing its air from both the ante-room and the hall. We changed it and placed it so we cut out the ventilation entirely from that ante-room, simply drawing air from part of the attic space directly over the hall. To my mind it was not supported as substantially in the second instance as it was in the first. In the first instance this ante-room was separated from a Masonic Hall by a fire-wall, and across the fire-wall we had put an I-beam and mounted the wheel on that. We put the disc wheel on so that it was pulling the air from the attic space directly over it.

Mr. H. M. Hart: Did you pull less air?

Mr. R. W. Pryor: The wheel was running at the same speed. I could not vouch for the amount of air handled because I didn't measure it. It was a proposition where we had to give them the same ventilation and work with the material in hand to correct the trouble. We were very well satisfied to get rid of the noise.

Mr. H. M. Hart: I am very much interested in that because that is a very interesting point. My 36-inch disc fans run at 600 r.p.m.

Prof. John R. Allen: It is a question of synchronism. There may be something surrounding the fan that gets into synchronism with the rotation of the fan. I remember a case of synchronism in a Corliss engine fly-wheel in which when the engine was being run at speed the fly-wheel struck the sides of the fly-wheel pit causing a deflection of over 1½ inches in a 20 foot wheel. By changing the speed of the wheel two revolutions it entirely corrected the difficulty.

Mr. Thomas Tait: This noise in ventilating fans is interesting to me right now, for the simple reason that I have a moving picture show place in which I am installing a No. 9 Multivane fan. I put two 12-inch I-beams across from wall to wall, the fan being practically in the center of the attic space. It really presents a splendid opportunity for the drum effect that we are talking about, and that's one reason why I asked about the thickness of the cork. I had a wooden platform made to rest on the I-beams which are set 4 feet apart. Between the bottom of the platform and the top of the I-beams I have placed two inches of cork, and one inch of cork between the wood platform and bottom of fan. The fan has not been operated as yet, so I cannot say anything about what the effect will be. Later

on I may report my experience in connection with this installation.

Secretary Blackmore: Before the discussion closes, I want to make some observations in regard to this matter for the consideration of the gentlemen here. In reading the paper and from a little talk that I had with one of our members, it seems that there are four distinct causes for noise in the setting up of an air apparatus of this kind.

The first has been touched upon by Professor Allen, vibration, which undoubtedly can be corrected by care in the setting of the fan so as to make use of the solidity of the building.

The next cause for noise is in the fan itself, which may be due to the defects in mechanical construction, to over-speeding or to the set of the blades in the fan.

The third cause is noise due to vibration in the air itself in a manner similar to that by which sound is produced in the pipe of an organ. In connection with this source of noise there may be a transference of the sound from the fan to a point distant from the apparent source of the noise, as in one case mentioned in the paper.

There is also noise due to the friction of the air traveling through the ducts and being deflected around the elbows.

Each one of these possible sources of noise require separate investigation. I offer these observations hoping that some of you gentlemen may by study ascertain the reasons for the noises where they occur and see whether effectual means cannot be discovered to remedy such troubles where they appear.

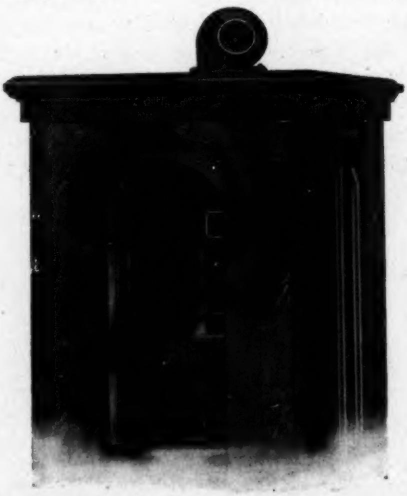
CCCLII.

VENTILATION OF TELEPHONE BOOTHS INCLUDING OTHER APPLICATIONS OF SMALL UNIT SETS

BY R. L. DOUGLASS, MEMBER

In the ventilation of telephone booths, there are more engineering and mechanical problems than at first appear.

The fan and motor must run noiselessly and for appearance sake and on account of the many installation conditions, the apparatus must be small.



The best results have been obtained with the housed type of blower, direct connected to and driven by an electric motor. The fan runs at 850 r.p.m. and delivers 35 c.f.m. to the booth. At this

speed, the fan and motor operate very quietly, but to insure all possible quietness, a felt pad is put between the fan base and the top of the booth.

The blower discharges air downward through the top of the booth, and here again is a point to be considered. Young people with plenty of hair are pleased with the cooling effect, but elderly people with bald heads complain of the draft. To overcome this, a special outlet piece so discharges the air in the booth, that perfect distribution of the air is obtained without perceptible drafts.

In this work, it is necessary that the outlets for the air are so designed that no sound can travel from the booth to the outside. To change the direction and velocity of the air, and thus deaden any sound waves in the exhaust, the air is forced out through brass slide gates near the floor in each inner wall of the booth. The air then goes up between the double walls of the booth, which changes both its direction and velocity, and out through slide gates placed near the top of the booth and in the outer side walls. In going through these gates the direction and velocity are again changed.

Current consumed costs only a few cents a day if run continually, but, if desired, arrangements can be made so the fan starts as booth is occupied and stops as door is opened when the occupant leaves the booth.

This system of booth ventilation is superior to the wall fan type, as by this system, the air is positively changed in the booth and not merely stirred up, as in the case of a closed booth with a wall fan in operation.

The foregoing is the application to individual booths, and telephone engineers have decided that it is more practical and economical in most cases to put an individual set on each booth rather

than to connect up several booths to one large fan. This latter method can be used, however, in which event, a slow running fan should be selected and a canvas connection used between the fan outlet and the piping. The piping should be made of fibre and baffles put in the supply pipe between the different booths, so cross talk cannot be heard between the booths whether or not the fan is in operation. In such an installation, it is advised to place the fan on a shelf near the booth rather than on top of one of the booths. A felt pad under the fan is also advisable.

While this method of ventilating a bank or nest of booths is possible and is in use, the matter of convenience and cost point to the advisability of the single booth system.

This same general method of ventilation may be used for ventilating phonograph demonstration rooms. On account of the large use of talking machines, there are being constructed in some large distributing agencies for talking machines and records, a number of sound-proof individual booths, so that the customer can be taken in a room and listen to the desired records without taking up too much space, and without annoying other people.

MOVING PICTURE MACHINE BOOTH VENTILATION

The laws in various states differ somewhat on the requirements of ventilating operating rooms. Illustration shows an installation made in Philadelphia where the law requires both positive and gravity ventilation. You will note the electrically driven exhauster,

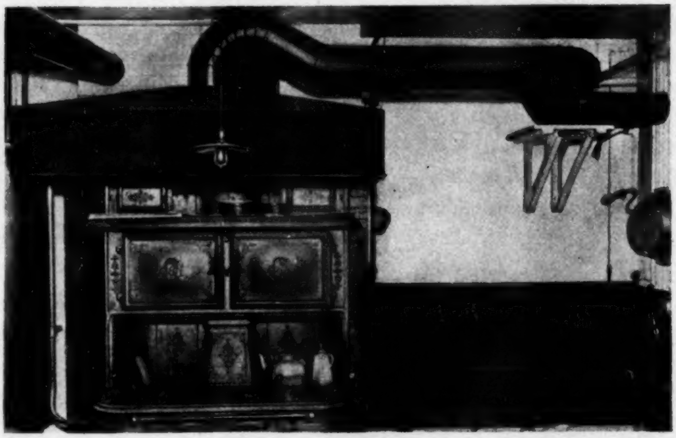
exhausts air from the top of the booth and blows it into a duct. You will see also that connected to this same duct is a riser from the blower for gravity ventilation.

This matter of ventilation in operating booths for moving picture machines is not entirely a matter of ventilation, but it also reduces the fire risk. In case fire started in the operating room, the tendency would be for the flames to go out through the ventilating system in the top of the booth, rather than into the main room, thus avoiding the great danger of panic.

LOCAL VENTILATION FOR INDIVIDUAL ROOMS

The illustration shows the installation of a small motor-driven exhauster for ventilating two closets in the toilet room. The top of the closets were closed over, the air being pulled in through the general toilet room under the bottom of the doors of the closets themselves. The top of the closet being the only inlet for light, a glass cover was used.

KITCHEN VENTILATION



The illustration shows the installation of positive kitchen ventilation in a private house. The use of the small electrically driven exhauster allows, at moderate cost, the installation in private residences of the same positive ventilation found in hotels and restaurants.

A matter for consideration is the ventilation of kitchenettes in high grade apartment buildings. As far as the writer knows, this has not been included in ventilation plans, at least to any degree, and it certainly would be well worth consideration in high price apartment houses.

In this paper the only application particularly new is telephone booth ventilation, the other uses of the small electric blower bringing out the possibilities of local ventilation by unit systems.

DISCUSSION

President Lewis: I believe the purpose of this paper was to accentuate the present and recently developed availability of small economical ventilating sets for many places. I want to call attention to the illustration of the ventilation of a range hood. We often have large installations of ranges with very heavy and expensive canopies coming six or eight feet below the ceiling and furnishing a place for dirt and dust to accumu-

late above their sloping or horizontal parts. Why not make a room above the range extending clear to the ceiling and put a fan right inside of that room? Then there is no flat surface above to collect dirt and grease. It costs less and it looks better.

Mr. R. W. Pryor, Jr.: I think that the open ceiling that you refer to would be a very good place for a fire to start as grease would accumulate up there. In apartment houses I have known people to put cooking utensils up on a shelf when they were out of service and a considerable amount of grease accumulated on them from the cooking on the gas range. If such a condition did exist the grease would certainly accumulate in such an open space as suggested, hence it seems to me it would produce a fire hazard.

Secretary Blackmore: When this paper first came to my notice I had some correspondence with Mr. Douglass. I felt that he had stopped short by reason of the fact that he had not treated the subject of ventilation of urinals, which are one of the most difficult things to ventilate and have been the most inadequately ventilated of any appliances we use. You will scarcely go into a hotel where there is a public urinal that is not offensive. I asked Mr. Douglass if he had made any studies along that line, and if he had whether he would not formulate something by way of suggestion? He said he would take it up at some future day and see if he could solve the problem; and if so would be pleased to present another paper.

Mr. H. M. Hart: Our President has called attention to one fact that I think might be emphasized a little more strongly; and that is the advisability of installation of small units in ventilation. I think the tendency has been in the past to try to accomplish too much from one unit; to try to install one unit to accommodate too many varying conditions.

In a hotel, for instance, they will put in a ventilating apparatus to ventilate a cafe or grill room which is perhaps in use twenty hours of the day, and they will use the same fan to ventilate a banquet room which is used perhaps four hours a day. That is not conducive to economy and sometimes leads to complications in trying to get good results with reference to temperature, humidity, etc., because the conditions in different parts of the building are not the same. I think they should be treated as individual and separate conditions by the application

of individual and separate units which will result in greater economy of operation as well.

I know of hotels that are operating very large fan units 20 to 24 hours a day because some small portion of the rooms ventilated are occupied for that length of time; while the larger part of the rooms ventilated are only occupied a small portion of the time. This is certainly not economy.

President Lewis: I think Mr. Hart's remarks are very well put. I think all of us have seen fans designed for buildings in which the distributing duct system was wrong and where they would have saved money if the units had been divided up.

Now in dividing up the next difficulty that we encounter is the next question. When they can make an induction motor that does not squeal they will have accomplished a great aim. We need an associate member who is an electrical expert who can do that.

CCCLIII.

AIR OZONATION

MILTON W. FRANKLIN

The subject of air ozonation may be divided into (1) ozone as an adjunct to ventilation; (2) destruction of odors from industrial plants such as glue factories, fertilizer plants, slaughter houses, fish marts, etc.; (3) adjunct to refrigeration in the practice of cold storage and food preservation.

VENTILATION. The application of ozone to ventilation has attracted much attention recently owing to the publication of a multitude of conflicting opinions concerning its merits. This confusion is due to several circumstances. In general, the proponents of ozone have claimed too much and have advanced many contentions, either insufficiently supported or in the very nature of things unsusceptible of proof. On the other hand, the opponents of ozone have attacked these claims with great energy and often have gone so far as not only to deny any usefulness whatever to ozone, but positively to affirm its harmfulness and dangerous character. In many cases the attacks on ozone have been directed against imaginary claims that were never made and much of the evidence against ozone is based on laboratory experiments which bear little or no resemblance to actual working conditions and therefore can scarcely be considered as authentic.

A careful and unbiased investigation of all the evidence accessible in the extant literature in connection with the theory and principles of ventilation hygiene must result in the conviction that ozone, properly applied, is capable of advancing greatly the art of ventilation and that it is incapable of harming persons exposed to its influence.

At the IX Congress for Heating and Ventilating held in Cologne in June, 1913, two notable papers were read: one by Prof. Czap-

lewski (1), and the other by L. Von Kupffer (2), which presented in detail the present status of the question and which elicited the following comment from Dr. Ing. H. Rietschel, the honorary president of the Congress:—

". . . . . .We have heard with conviction that ozone has been used in numerous cases with the best of results for ventilating plants and that it can be used for such purposes; also that in the diluted state in which it is to be used it cannot be considered as being harmful. We shall, therefore, devote our undivided attention to ozone and its application for ventilating purposes."

The subject of ozone in ventilation was treated by the present writer in a paper presented at the Fourth International Congress on School Hygiene (3), in which were described some experiments which demonstrated that many odors arising from organic sources were destroyed and not masked by ozone.

1. The experiments described in this report show that ozonized air does not merely mask offensive odors of varied nature, but that it actually destroys them.

2. It is shown that the odor of some common food materials, onions, garlic and limburger cheese, are destroyed by ozonized air.

3. The odors resulting from decayed raw food materials, fish, eggs, meat and oysters, are destroyed by ozonized air.

4. The offensive odors of fertilizers are destroyed by ozonized air.

5. Several definite chemical compounds which contribute to the odor of feces, perspiration of feet, rancid butter, sauerkraut and limburger cheese: namely, skatol, valerianic acid and butyric acid, are also destroyed by ozonized air.

6. The persistent odor of tobacco smoke as absorbed by the clothing is destroyed by ozonized air and the yellow color produced by blowing smoke through cloth is bleached by ozone.

The following tabulation presents some of the materials upon which the experiments were performed:—

	Odor Before Treatment with Ferrous Sulphate Solution.		Odor After Treatment with Ferrous Sulphate Solution.	
Odor from:	With air:	With ozone:	With air:	With ozone:
Onions	Strong onion	Strong ozone	Strong onion	None
Garlic	Strong garlic	Strong ozone	Strong garlic	None
Limburger cheese ...	Strong limburger	Strong ozone	Strong limburger	None

Decayed fish	Very offensive	Strong ozone	Very offensive	None
Decayed eggs	Very offensive	Strong ozone	Very offensive	None
Decayed meat	Very offensive	Strong ozone	Very offensive	None
Decayed oysters	Very offensive	Strong ozone	Very offensive	None

According to the modern theory of ventilation the only baneful factors in "vitiated" air are heat, moisture and odors. If the air is stagnant and motionless its power to absorb heat and water is not utilized fully: hence, a fan which circulates the air generally adds much to the comfortableness of a poorly ventilated space. The ancient beliefs that excess of carbonic acid gas and deficit of oxygen accounted for the distress attendant upon inadequate air supply have been dispelled by the published labors of Halldane, Hill, Pfluegge, and others. It has been shown that in the worst cases the available oxygen is far in excess of the demand and that CO_2 is harmless in the concentrations likely to be met. The conviction once prevalent that organic "crowd poisons" were the guilty factors likewise has been abolished. Billings, Mitchell and Bergey (4) have added much to the knowledge of this aspect of ventilation. The most recently demolished belief was that bacteria existed as a menace in rebreathed air. The works of Pfluegge (5), Chapin (6), Doty (7), and of Winslow and Robinson, have fairly disproven this contention.

The modern practice of ventilation, then, clearly is concerned only with absorbing the almost invariable quantity of heat produced per capita of room occupants, of removing the moisture transpired, and of destroying the odors generated and which are due to the presence of people, animals and organic substances, including food stuffs, especially when in a state of putrefaction.

Heat and moisture absorption have received weighty consideration from the engineering profession and may readily be accomplished with accuracy and certainty in any given set of conditions. Odor elimination, by no means the least important, may be accomplished best through the agency of ozone. Supplying too great an amount of air in a ventilating system constitutes an engineering and hygienic error as well as does supplying too little air. Correct engineering practice consists in accomplishing an end in the least costly manner compatible with correct performance of function; and too much air means dangerous drafts, waste, and inefficiency.

Ozone renders possible the elimination of odors which often cannot otherwise be removed at all, or possibly only by the providing of a prohibitive excess of air with the attendant probability of drafts and low economy. But primarily, ozone is most useful in those myriad instances where idealized ventilation systems are simply beyond the question. In these all too numerous though unfortunately inevitable places, where perfect ventilation is impossible, ozone will produce a condition of the air unattainable by any other known means. It imparts a freshness and "tang" to the air, rendering it comparable with that in the most favored natural localities.

Ozone in general destroys and does not mask organic odors as has been shown above.

It remains then only to know that ozone is inoffensive and incapable of harming persons breathing it, in such quantities as are used in ventilation, before justifying and recommending its use.

Cramer (8) stated at the Frankfurt Congress for Heating and Ventilating:—

"In earlier times we assigned to ozone a poisonous influence on animal organisms, while recent investigations have shown that the ozone is poisonous only when made chemically and not pure. A mixture of chemically pure ozone with atmospheric air, can, if the percentage of ozone is not too concentrated, never hurt an organism, as statements from doctors and scientists show. Only in very concentrated form does it attack the lining of the mucous membrane."

No single instance of harm to a person from the proper use of ozone in ventilation has been recorded, but on the contrary, all adverse opinions have been deduced, by inference, from laboratory experiments performed with very high concentrations, while all efforts to produce harm experimentally with weak ozone have failed. Jordan and Carlson report that twenty-six animals, exposed for fourteen days, during nine hours each day, to concentrations high enough to cause irritation of the eyes and nose, suffered no ill effect whatever. Hill cites the cases of the numerous workers in the London underground tubes, who have shown no ill effect in three years. Gminder cites the unharmed workers in the spinning mills at Reutlingen. Erlwein (9), says:—

"It is a fact at any rate that there have never been proven cases of sicknesses of a serious character due to breathing ozone air. Special attention is called to a large water sterilization plant operating for more than ten years, where the working force is

constantly moving in an atmosphere which is more strongly mixed with ozone than is ever found in actual ozone ventilation installations. There has never been a case where these persons have been forced to be on sick-leave due to the high ozone concentrations in the plants."

Numerous similar instances of prolonged proper use of ozone without a single complaint are in existence.

Efforts to disinfect occupied rooms have shown that ozone, in concentrations sufficient to produce sterility of the cultures, is irritating to the mucous membranes of the respiratory tract and in fact will produce death in guinea pigs, but as pointed out above, sterilization of atmosphere has little sanitary value and it must be remembered that no known method of room disinfection can be practiced in the presence of room occupants. Sulphur dioxide, hydrocyanic acid and formaldehyde would produce death in guinea pigs more rapidly than would ozone. It has been shown that ozone in high concentrations is a local mechanical irritant but there is no evidence to justify the opinion that it is injurious in low concentrations.

Toxicologists recognize two distinct classes of poisons: namely, physiological or chemical poisons and mechanical poisons. The former act by being absorbed into the system and causing trains of phenomena through the nervous mechanism; the latter act merely by causing local destruction of the tissues with which they come into direct contact. Strychnine is an example of a chemical poison; its action is dependent only on the quantity ingested and is wholly independent of its concentration. One grain administered internally will cause death, whether it be taken pure or copiously diluted with water. An example of a mechanical poison is sulphuric acid; its only action is a local destruction of bodily tissues, and a quantity which would cause death, if administered concentrated, might be taken with impunity when accompanied by a sufficient diluent. Ozone has been shown to be a mechanical irritant, but to deduce the result that because strong ozone is harmful, weak ozone also must be harmful, is equivalent to arguing that because 50 per cent. oxygen breathed for a certain period will cause death from inflammation and edema of the lungs, the 20 per cent. oxygen, such as we inspire at every breath, is also poisonous.

Experiments conducted by Jordan and Carlson to determine whether or not ozone in low concentrations, somewhat higher than

might be used in ventilation, is harmful, have resulted in the following conclusion:—

"All the animal groups showed some increased body weight, but the increase during the ozone period is practically the same as during the control period. Slight differences are of no significance. Hence, as regards appetite and body weight, the results of the tests are negative, the ozone appearing to have neither a favorable nor an unfavorable influence. This applies also to the general conditions of the animals. The cats did not seem disturbed, even when the ozone concentration caused some restlessness in the rabbits, guinea pigs and rats. In all other respects the animals appeared to be normal."

This is a convincing demonstration of the harmlessness of even too high ozone concentrations. The animals were exposed for fourteen days to ozone, following a period of fourteen days confinement for control observation, but in spite of the prolonged close confinement and extremely inadequate ventilation (sixteen cubic feet per hour per animal), they thrived as well during the second fourteen days with rather too strong ozone as during the first fourteen days.

So far as is definitely known the value of ozone in ventilation is not due to any beneficial effect upon the human economy but to the circumstance that it destroys much that may be objectionable or harmful in foul air. The air is not better because it contains ozone but because this ozone signifies the absence of such organic effluvia as otherwise would be obnoxious.

The well established fact that ozone is a powerful germicide in the presence of water has led to much experimentation and speculation on its possible power of destroying the bacteria in the air. Wyssokowitz (10) experimented with chemically formed ozone and found a diminution in the air bacteria, but owing to the many possible errors in his method of procedure his results are frankly admitted to be of little value. He attributed the effect observed to the simultaneous formation of acid, which rendered the soil unsuitable for the growth of bacteria. Froelich (11) found some diminution in air bacteria with strong ozone. Sonntag (12) found no effect of ozone in low concentrations on dry bacteria, but with extremely high concentrations (13.5 gm. per cbm.) the bacteria were destroyed. Konrich also obtained negative results with cultures dried on strips of filter paper and on glass rods. Labbé and

Oudin produced diminution in the bacterial count but they admit that their results are of little importance, owing to possible sources of error.

Bail (13) has experimented quite extensively and states:—

"Even strong ozonization of the enclosed air with circulation never allowed the beginning percentage of the air as regards bacteria to be reduced in a conclusive manner. The bacteria in the air were determined either on open agar plates, or else by passing known quantities of air through gelatine. Passing air, ozonized as much as possible in the apparatus, through tubes having powdered bacteria or through loose sand containing bacteria gave no conclusive indication of an effective action of the ozone on the bacteria. Experiments to change the humidity of the air by evaporating water during ozonization and circulation produced no changes in the results."

Jordan and Carlson found little or no effect on plated and dried cultures with low ozone concentrations, but in four tests on the bacteria suspended in the air, three showed an average decrease of 53 per cent. and one showed an increase of 10 per cent. Franklin (14) showed a decrease in the bacteria suspended in the air but the ozone concentration probably was relatively high.

The general evidence of laboratory experimentation seems to indicate that low concentrations of ozone, at least, have no consistently demonstrable action on dried bacteria, whether in cultures or floating in air. On the other hand, there is a considerable amount of evidence to the effect that in storage cellars and similar places the growth of fungi, molds, and similar micro-organisms is impeded, if not totally repressed, by even weak ozone concentrations applied for prolonged periods. A possible explanation is afforded in the work of Trillat (15), who has shown:

"That the transport of pathogenic microbes in the air is effected especially by the damp which contains, in an infinitesimal state, traces of gas-aliments. Moreover, it would seem that the air, when it fulfills certain conditions of dampness, of chemical composition, of temperature, and of age of microbes, is capable of being fertilized directly by the contact of a microbian source. Up till now it was thought, according to numerous observations, that for microbes to be transported by the air it was necessary to project them into it by some mechanical action, such as pulverization or any other means, the effect of which would be to detach them from their support. Contrary to this notion, Trillat and Fouassier have

established experiments demonstrating that when the superposition of certain factors takes place, the sowing of the air is performed in the same manner as that of a bouillon culture, merely by the play and movement of the invisible vesicles which constitute the humidity of the air. In an infinitely feeble volume of about one hundred-thousandth of a cubic millimeter these tiny drops are uninfluenced by the action of the force of gravity. They are always mobile under the influence of the least variation of temperature. M. Trillat and Fouassier have shown how the contamination of the air takes place in a closed and tranquil space, without the intervention of the presence of dust or of any mechanical means, as was believed up to the present time."

It seems probable that the gradual lessening in the bacterial count in the air of places that have been ozonized for some time is due, not to direct influence of ozone on the bacteria, but to the alteration in the air as a culture medium and also to the fact that the myriad cracks and crevasses in the walls, ceiling, hangings, furniture, etc., which harbor cultures that constantly supply bacteria to the air, are gradually exhausted. This would account for the discrepancy between laboratory tests of brief duration and actual prolonged trials.

ODOR DESTRUCTION. In addition to the odor destruction tests outlined above and already published, further tests have since been made with casein and with tobacco smoke. The casein tests were undertaken with the object of destroying the odors arising from a factory producing about 500,020 lbs. casein per month. This material had a very bad, nauseating odor. In drying the material, air is passed over it or through it, and this takes up part of the disagreeable odor. This air then passes up a stack and out into the atmosphere, where it proves a nuisance to the neighborhood. The problem is to destroy the odor before it passes up the stack.

Tests were made on the effluvium from the casein to determine whether ozone would affect it. For this purpose about 15 gm. were put into a Petri dish under a bell jar. When the air had become saturated it was caused to displace the water in a Wolff bottle. A measured amount of this effluvium was then allowed to mix with a measured amount of ozonized air of known concentration. Several tests were made, using various quantities of ozone, any odor due to excessive ozone being removed with ferrous sulphate. In each case the odor due to casein was destroyed. The least quantity of ozone which sufficed was 1.84 mg. per liter of

effluvium; 1.75 mg. per liter left a slight trace of the odor. The results are presented herewith:

1. 1 L. of effluvium was entirely deodorized by .47 mg. of ozone, with a distinct excess of ozone.

2. 11 L. of effluvium were entirely deodorized with .41 mg. of ozone or .037 mg. per L. with excess of ozone.

3. 14 L. of effluvium were deodorized with .171 mg. of ozone or .012 mg. per L. with excess of ozone.

4. 0.0057 mg. ozone per liter of effluvium materially lessened the odor but did not destroy it entirely.

CONCLUSIONS. The proportion of air to casein in the experiment was less than in the most unfavorable case that the factory conditions exhibit. The casein used was in a much more advanced state of decay and probably had odors that were far stronger than are ever obtained at the factory. Complete elimination of the odor was the object in the experiment, and this was obtained at will. The qualitative tests which preceded the quantitative tests demonstrated that actual destruction and not masking of the odor was attained.

SMOKE. The destruction of the odor of stale tobacco smoke and of old moist cigar stumps has always constituted a most graphic illustration of the power of ozone. Rooms in which much smoking has occurred retain the odor of tobacco in the walls, hangings and furnishings and this odor is enduring and persistent. Experiments in which it was shown that the odor imparted to cheese cloth by tobacco smoke could be destroyed by ozone have been published in the previously cited paper (16). There seems to be some difference of opinion, however, regarding the effect of ozone on the smoke present in an occupied room during the actual smoking, and where the ozone is of such strength as to be comfortably borne by the room occupants.

Hill and Flack (17) noted that the apparent density of the smoke diminished and that the odor disappeared. Kisskalt, Schwartz and Münchmeyer (18) noted a lessening in the smoke density and total disappearance of the odor. Cramer (19) states with regard to experiments performed on a large scale:—

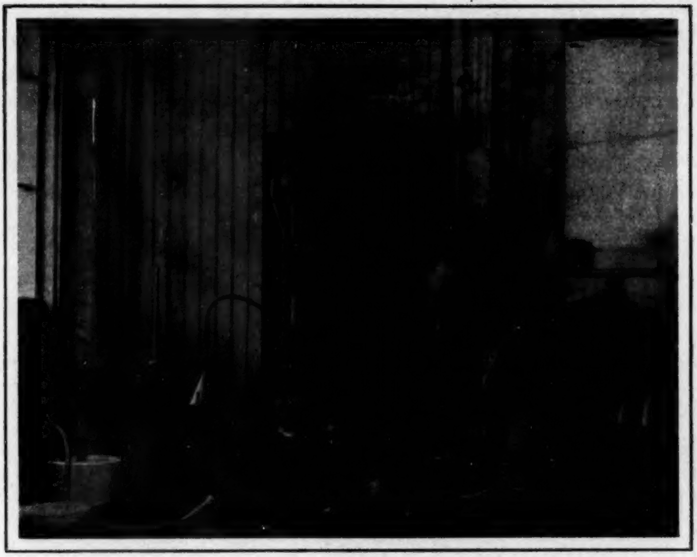
"All that could be clearly demonstrated was the fact that the smoke haze became appreciably lighter and that the pungent characteristic of the smoke disappeared, rendering it no longer irritating to the eyes."

Czaplewski (20) states:—

"In our own tests with stronger ozone concentrations, cigarette smoke was entirely destroyed in a room so as not to be perceived by a person entering the room from the outside. There was no 'after' smell and tobacco smoke on clothing is disposed of by ozone."

Smoke consists of particles of carbon and of various volatilized pungent and aromatic substances. Only the latter give taste, smell and irritating properties to smoke, the carbon contributing most of the visibility. The volatile elements in smoke exist in the gaseous form: i.e., in a state of molecular subdivision, but the carbon particles exist in the shape of molecular aggregates, each of infinite size compared with the molecules themselves, otherwise they would not be visible. Ozone can combine only with the volatile elements in smoke. It thus renders it odorless, tasteless, and incapable of causing irritation, but it cannot burn the carbon which in any event is totally inert and harmless. Numerous tests with actual smoke have shown this to be true.

In my own tests I have observed that when the ozone is turned on in a smoke laden atmosphere the density of the smoke lessens and the odor and pungency disappear, the smoke being entirely undetectable excepting for its visibility. For some time I have suspected that the apparent diminution in visual density might be due to stirring up of the air by the fan which is attached to all the ozonators with which I have experimented in this direction. Some experiments were performed to determine whether or not ozone actually diminished the smoke density. The general arrangement of the apparatus is shown in Figure (1). Wolff bottles of 2 L. capacity, and furnished with a tubulure at the base, were filled with water. One of the necks was stoppered and the other attached by a rubber tube to a glass funnel inverted over a quantity of burning tobacco. The tobacco was burned on a thin flat iron plate by means of a gas burner placed underneath. The funnel was supported with its rim about ½ inch above the plate and directly above the tobacco. When the tubulure was opened and water permitted to flow from the Wolff bottle, the air which replaced the water flowed under the edge of the inverted funnel and over the burning tobacco, whose smoke was carried along with the air. In this manner each of two bottles was half filled with a dense cloud of smoke. One of these bottles was then connected to the ozone line and the remaining water replaced by ozonized air, leaving about ½ inch of water in the bottom of the bottle. Into the



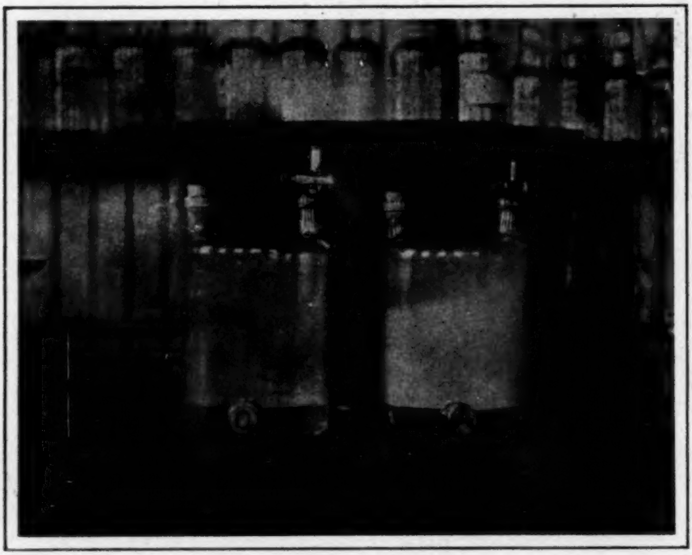
(Figure I.)

other bottle atmospheric air was introduced in the same manner. The bottles were then shaken to cause the water to mix the smoke and air thoroughly, and the bottles were placed side by side on a shelf and observed after various periods of time. The results are presented in the following tabulation:—

I	II	III	IV	V	VI
Test No.	Ozone mg.	15 min.	30 min.	1 hr.	4 hrs.
1	1.05	slightly clearer	slightly clearer	marked clearing (slight)	marked clearing
2	.92	slightly clearer	slightly clearer	slightly clearer	marked clearing
3	1.10	no difference	slightly clearer	slightly clearer	slightly clearer
4	1.13	slightly clearer (?)	slightly clearer	marked clearing	marked clearing
5	.96	slightly clearer	slightly clearer	slightly clearer	marked clearing (slight)

The remarks under columns III, IV, V and VI refer to the bottles containing smoke, air and ozone, directly compared with

the corresponding bottles containing only air and smoke. The tobacco was of a standard inexpensive "cut plug" variety sold in ten cent packages and was rather sweet, strong and moist. The amount of tobacco was very nearly 2.0 gm. in each case and was completely burned, the whole gaseous products of combustion entering the Wolff bottle. There was considerable condensation on the funnel at first but later this decreased greatly, as ascertained on weighing the funnel, and the results given are of the later tests. The smoke in the bottles was much denser than could be obtained in any room by persons smoking.



(Figure 2.)

It will be seen that in the bottle containing ozone the smoke, in general, cleared sooner than that in the bottle containing only air. The difference, though always unmistakable after several hours, was only occasionably quite marked. Figure (2) presents a case in which the difference was very pronounced. The amount of clearing after the lesser periods of time was so slight as often to be questionable, but in general it can be said that the ozone makes a slight reduction in the smoke density. In

each case the smoke settled slowly in a cloud, leaving the top of the bottle clear. The "conglomeration" noted by Cramer (21) was seen only in one test (No. 3) and then only faintly.

It might be concluded from the above tests that ozone is capable of lessening somewhat the visual density of tobacco smoke, but when it is remembered that the ozone concentration was about 1 gm. per cbm. it hardly seems probable on first thought that the clearing noted when ozone at a concentration not exceeding 1 mg. per cbm. is turned into a smoky room, is due alone to the action of the ozone. However, a consideration of the quantities involved indicates that this may well be true. In the tests the products of combustion of 2 gm. of tobacco were collected in the space of 2 L. in approximately 2 minutes. This would be equivalent to burning 41 kg. tobacco in a room of 41 cbm. (12 ft. x 12 ft. x 10 ft.) in 2 minutes. Five men smoking pipes in such a room would burn only 4.3 gm. in the same period. Thus the ratio of tobacco consumption in the above described laboratory tests and in this hypothetical case is approximately 10,000 :: 1, while the ratio of the ozone concentrations is only 1,000 :: 1, or in a similar actual case occurring in practice the amount of ozone would be about ten times more in proportion to the tobacco than in the tests described. Besides this there would be approximately 10,000 times as much air for the smoke to diffuse into and a marked clearing action is exercised by the air, which may be intensified by the action of the ozone. The estimates of the amounts of tobacco consumed are based on measurements of ten pipes and on timing different smokers. The average amount of tobacco (of the kind used in the experiments) held by the pipes was 1.62 gm. and the average time of smoking was 38 minutes. In all cases the odor of the smoke was markedly or even completely removed, leaving it odorless, tasteless and with no power to irritate the mucous membranes of the eyes, nose, or mouth.

Fragments of cloth were cut into strips 5 cm. x 8 cm. and suspended in a bell jar having a tubulure at the bottom and a neck at the top. The latter was connected to an aspirator and tobacco smoke was drawn in at the tubulure. After the smoke from 2.5 gm. of tobacco had permeated the cloth strips the latter were removed and examined; they smelled strongly of tobacco. They were then replaced in the bell jar and ozonized

air was drawn through for varying periods of time. The concentration was 1.03 mg. per cbm. The results were as follows:—

Test No.	Material.	Result.
1	Cheese cloth (thoroughly washed).	Thoroughly deodorized— 9 min.
2	Cheviot (cut from an old suit)...	Thoroughly deodorized—29 min.
3	Satin (cut from lining of old suit)	Thoroughly deodorized—18 min.
4	Duck (New)	Thoroughly deodorized— 6 min.

No. 1 became most strongly odorous with the same exposure as the others. After a rest of 12 hours No. 2 experienced a slight though distinct return of odor, which, however, disappeared finally with 5 minutes' additional ozonation. The comparative thickness and microscopic complexity of the cloth undoubtedly accounts for this phenomenon.

Cold Storage and Food Preservation. Czaplewski states:—

"A great field for ozone ventilation seems to open in the food industry, especially in the cold storage chambers of abattoirs. Ozone has been shown to have caused direct saving in many of these plants, the meat remaining fresh and sweet for a much longer period with ozone than without. In egg cold storage the ozone has given excellent results in that the disagreeable straw and box odors disappear, the eggs last longer, and fewer decay."

Bail (22) reports, referring to the Cologne abattoir:—

"Meat that had decayed was at least partially reclaimed by the ozone, the mold coating having disappeared."

Saint Père (23) states:—

"Only pure ozone should be used in food preservation. Pure ozone on decomposition yields only pure oxygen but this is not true of ozone contaminated with other gases. The latter gives a peculiar odor to eggs, meats, etc., due to the nitrogen oxide impurities. The odor fixes itself permanently in the moist parts of meats, as the muscular fibres, ruining the best qualities. This contamination in ozone does not harmfully affect fruits; the thickness of the skin is apparently effectively increased, thus protecting it against the cold which otherwise hinders ripening."

For most varieties of foods there exists a certain critical temperature below which they may not be stored without injurious freezing and above which they are liable to deleterious bacterial invasion. It is extremely difficult to maintain rooms at the

right temperature owing to the constant entrance and exit of operatives and because masses of material to be stored diffuse great quantities of heat on cooling down. The function of ozone is to limit bacterial activity at temperatures at which they might otherwise thrive.

EGG STORAGE. We have performed experiments with the preservation of eggs at ordinary temperatures and present the results herewith:—

Preliminary tests were made to determine the effect of ozone on egg albumin and to note the effect of vacuua on eggs. The eggs in all of the tests were from white Leghorn hens and were laid on the morning of the day of the tests.

The albumin of three eggs was well mixed, diluted with an equal quantity of water and divided into two parts. One part was put into a Petri dish, 6 inches in diameter and 5/8 inch deep and placed under a bell jar, (9 inches in diameter by 12 inches high) with openings at the top and near the bottom at the side. Glass tubes provided with stop-cocks were inserted through corks in these openings; the one passing through the top opening extending downward inside the bell jar almost to the Petri dish. The lower glass tube was connected to an aspirator and ozonized air containing 5 gm. per cbm. was drawn from the upper tube over the Petri dish at the rate of 1 cbm. per hour. The total amount of air was 170 L., ozone 850 mg., period, 10 minutes.

The albumin coagulated considerably and the whole mass turned a weak yellowish grey color which was distinctly noticeable but not pronounced. There was no odor of ozone in the resulting coagulum. Straining and weighing showed that the coagulum represented 27.4 per cent. of the total albumin.

The remaining half of the albumin solution was treated in the same way with atmospheric air instead of ozonized air. The amount of air and the period were the same and there was 16.4 per cent. coagulation but no discoloration.

Ten eggs were weighed, numbered, and placed under the bell jar in a Petri dish. The jar was then evacuated to 0.46 mm. hg. and kept in this state for two hours, when the pressure had risen 2.37 mm. owing to evaporation from the eggs, none having broken. The air was then slowly introduced till atmospheric pressure was reached and the eggs removed and weighed.

Wt.	1	2	3	4	5	6	7	8	9	10
Gms.	57.13	63.06	68.75	61.78	61.61	62.62	54.79	57.23	53.80	57.43
Loss %	.402	.365	.465	.461	.372	.335	.381	.540	.473	.400

Mean wt. before .... 59.82 gm.
Mean wt. after .... 59.57 gm.
Mean loss gms. .... .25 gm.
Mean loss % .... .42%

These eggs were among the checks in the following experiments. Ten salt mouth bottles of 1 L. capacity were fitted with corks ½ inch thick, boiled in paraffine and provided with two glass tubes with stop-cocks. Two eggs, weighed and numbered, were placed in each bottle and the corks replaced and sealed with paraffine. The bottles were exhausted to 0.59 mm. hg., after which air containing 320 mg. ozone per cbm. was slowly introduced. Ten control bottles were prepared in precisely the same way, with the exception that the air contained no ozone, and furnished with eggs. The bottles were numbered and put away in a dark room and at periods of ten days one ozonized bottle and one check bottle were opened and the eggs examined and compared. One egg from each bottle was boiled and the other fried in Crisco and wherever possible all of the eggs were eaten. The temperature varied from 16 deg. C. to 25 deg. C. during the whole period.

Ten days:—There was no ozone left in the bottle. Both eggs were all right in every respect; loss of weight, .10 per cent. and .17 per cent. The control eggs were all right; loss of weight, .19 per cent. and .24 per cent.

The remaining bottles were then evacuated and ozonized as at the beginning of the test and the control bottles evacuated and filled with air. In two bottles the eggs cracked and were discarded.

Twenty days:—The ozonized eggs were all right in every respect; loss in weight, .45 per cent. and .49 per cent.; no ozone left. Of the unozonized eggs the boiled one tested like an old storage egg but the fried one seemed all right; the bottle had no smell; loss in weight, .57 per cent. and .56 per cent.

Thirty days:—The ozonized eggs looked, smelt and tasted all right; no ozone left; spot in both shells because eggs had not been turned; loss in weight, .84 per cent. and .55 per cent.

The unozonized bottle smelt from mildew; eggs looked weedy and spoiled; neither could be eaten; half of the inside of shell

was black from lack of turning; loss in weight, .72 per cent. and .75 per cent.

Forty days:—Ozonized eggs both good in all respects; loss in weight, .65 per cent. and .98 per cent.; no ozone left.

The unozonized bottle smelt from mildew; both eggs thoroughly bad; could not be eaten; loss in weight, .88 per cent. and .96 per cent.

Fifty days:—Ozonized eggs both all right in all respects; no ozone; loss in weight, 1.25 per cent. and 1.12 per cent.

Unozonized eggs essentially same as at 40 days.

Sixty days:—Ozonized bottle showed slight trace of mildew; shells slightly mildewed; eggs both eaten but did not seem altogether fresh; loss in weight, 1.65 per cent. and 1.52 per cent.

Unozonized eggs essentially as in 40 day test but more pronounced; loss in weight, 1.38 per cent. and 1.76 per cent.

Seventy days:—Smell of mildew in ozone bottle; boiled egg could not be eaten but fried egg was eaten and tasted somewhat stale; loss in weight, 1.59 per cent. and 1.69 per cent.

Unozonized eggs were thoroughly rotten and mildewed; strong H_2S.

It should be noted that the corks were not tight after the first trial; the ozone disappeared in a short time, the period lessening after each treatment; the ozonized eggs lasted about twice as long as the unozonized eggs; the temperatures were very high throughout. Further tests with ozone supplied constantly are to be reported later.

Fresh eggs are covered with a thin mucilaginous envelope which renders them airtight but after a time this dries and desquamates, leaving the porous shell unprotected. Then follows a period during which evaporation takes place and much of the water of the egg passes through the shell, being replaced by air from without. This air carries a variety of enzymes and other micro-organisms through to the interior of the egg and it is probable that all the putrefactive changes in the egg are due to the activity of these organisms because the contents of fresh eggs are known to be absolutely sterile. Ozone by lessening the number and activity of these organisms inhibits the putrefactive processes to which stored eggs are otherwise liable.

CONCLUSIONS:—From the evidence presented above, the following conclusions may be drawn:—

1. Ozone destroys the odors of certain food stuffs and other organic sources of odor.

2. Ozone is in no sense poisonous, though in great concentrations it is capable of causing local irritation of the mucous membranes with which it comes in contact.

3. Prolonged ozonation is capable of ridding, at least in a measure, the atmosphere of food storage rooms of germ life, probably through rendering it an unsuitable medium for their support.

4. Ozone is a valuable adjunct to ventilation, its function being the destruction of odor with consequent partial purification of the air; there is nothing either in the theory or in recorded experience to warrant its use for curtailing ventilation.

5. Eggs may be preserved longer with the aid of ozone than under similar conditions without.

6. The analogy between laboratory tests and actual practical applications is often so obscure and replete with modifying factors that the extremest care must be exercised in applying the results of experimental observations to practice.

References.

1. Prof. Czaplewski, Gesundheits Ing., Aug. 2, 1913.
2. L. Von Kupffer, Gesundheits Ing., Aug. 16, 1913, p. 605.
3. M. W. Franklin, Fourth International Congress on School Hygiene.
4. Billings, Mitchell & Bergey, Composition of Expired Air and Its Effect Upon Animal Life, Smithson. Inst., 1895.
5. Pfluegge, Zeit. f. Hyg. u. Infekt. Krankh. 49, p. 363, 1905.
6. S. Chapin, Sources and Modes of Infection, p. 314.
7. Doty, Med. Record, N. Y., Nov. 2, 1912, p. 891.
8. Quoted from Czaplewski, ibid.
9. Erlwein, Zeit. f. Sauer u. Stickstoffindustrie, 1913, Nos. 7 and 8.
10. Mitt. a.d. Bremer Heilanstalt, Wiesbaden, 1890.
11. Electrotech. Zeit., 1891, p. 340.
12. Zeit. f. Hygiene, Vol. 8, 1890.
13. Prag. med. Wochenschr., 1913, No. 17, p. 216.
14. M. W. Franklin.
15. A. Trillat, Orig. Comm. VIII. Int. Cong. Appl. Chem. 19, p. 71.

16. M. W. Franklin, ibid.
17. Hill & Flack, Proc. Roy. Soc. Ser. B. Vol. 84, p. 404.
18. Kisskalt, Schwartz & Münchmeyer, Chemiker Zeit., 1912, No. 129.
19. Cramer, Gesundheits Ing., 1909, p. 498.
20. Czaplewski, ibid.
21. Cramer, ibid.
22. Bail, Prog. Med. Wochenschr., 1913, No. 17, p. 217.
23. St. Père, Revue Generale de Froid, No. 34, March, 1912.

DISCUSSION

Prof. John R. Allen: The President has remarked that it is a very valuable paper, but there is one statement that he makes here that I question. In the first place, I have consulted with our Physiological and Psychological Departments of the University of Michigan and they say that there is no instrument known by which you can absolutely measure odors. The ordinary way to measure them is by an olfactometer which employs the human nose as its means of measurement, and that is more or less inaccurate. The author here states that ozone acts by oxidizing the odors. Now in the first place we do not know what causes odors. We talk about the fine distribution of matter. When you come to radio-active materials and think of the infinitely small amount radiated from them as compared to the energy that is given off; when you come to study smells such as the odor that is given off by a piece of sandal-wood that has been giving off an odor for two thousand years; when you come to imagine how small must be the particles that have been given off from that sandal-wood during all that long period and that it is still giving off particles sufficiently powerful, however minute, to affect the olfactory membrane, you will see that you are dealing with a very difficult subject.

It is not possible, it appears to me, at the present time to tell whether we oxidize odors or not, because we do not know the chemical composition of odors. We are dealing with too minute particles to be able to analyze them; and the question arises in my mind whether after all the ozone does as a matter of fact act by oxidation. It is quite probable that it acts by what we call "olfactory compensation." It is a well-known fact that you can compensate one odor with another. Take, for instance,

deodorized iodoform which has in it some material which neutralizes so far as the mucous membrane is concerned the smell of iodoform. The smell is there just the same, but the other smell deadens it so that so far as your nervous system is concerned it counteracts it; and it is probable that the action of ozone in the cases mentioned in the paper is simply through olfactory compensation.

All this information is reflected light which I obtained from our Physiological and Psychological Departments before I came over here.

President Lewis: While Professor Hoffman is getting his paper ready, I am going to express my thanks to him and to Professor Allen for inaugurating a custom which I believe is a very good one and which I hope will be followed by others of our membership, namely, that when papers are sent out prior to the meeting, the members will consider them and make written reports or prepare themselves to make verbal reports so that we may have the advantage of the opinions of experts in any particular line. The more we do that, the more rapidly will we elevate the plane of our proceedings.

Prof. J. D. Hoffman: Quoting: "According to the modern theory of ventilation the only baneful factors in 'vitiated' air are heat, moisture and odors."

Also: "It has been shown that in the worst cases the available oxygen is far in excess of the demand and that CO_2 is harmless in concentration likely to be met with. The conviction once prevalent that organic 'crowd poisons' were the guilty factors likewise has been abolished."

Also: "The most recently demolished belief was that bacteria existed as a menace in re-breathed air."

Also: "The modern practice of ventilation, then, clearly is concerned only with absorbing the almost invariable quantity of heat produced per capita of room occupants, of removing the moisture transpired, and of destroying the odors generated, etc."

According to these quotations, there is no question of doubt concerning the wholesomeness of respired air if it is only kept at the proper temperature and humidity and kept free from odors. Let us imagine two men, of equal normal health qualifications, except that one has lost the sense of smell. These men are subjected to an atmosphere heavily charged with offen-

sive odors. Will the man who has the normal sense of smell receive the greater injury? Certainly odors are not harmful. They merely indicate the trouble. I am personally inclined to regard the sense of smell as an easily applied proof of the stagnation of the air, comparable in a way, with our CO_2 test, which is a proof of the amount of fresh air supplied and the distribution of the air in the room. Eliminating odors as being merely unpleasant and not harmful, how about temperature and humidity? Surely heat and water are not baneful factors or harmful to the human body, except as taken in extraordinary amounts.

Again, no person contends that an otherwise pure atmosphere having less than normal oxygen, or more than normal CO_2 will be fatal, or immediately harmful, although its subtle influence upon health, by long continued applications to these conditions, is still to be proven. Again, the term "crowd poisons" —what are they? And if we do define them, do we know enough about them to be sure there are no such poisons?

Again, is it conclusively proven that bacteria does not exist in respired air? The careful observer will insist that judgment upon these most vital points, should be exceedingly deliberate.

I wish to add my word of appreciation for the work done by the experimenters quoted. I have read of these experiments and have admired the painstaking carefulness employed. I am a believer in the sincerity of all the persons employed in the work, and accept the results as genuine, but cannot accept the conclusions of some of them.

To subject persons in normal health, to bad air conditions for a few hours or days, and then draw conclusions as to the permanent health effects, is not good logic. Because persons may stand certain unsatisfactory surroundings for a brief period without apparent harm does not argue that the same persons could continue this indefinitely.

Concerning bacterial and germ poisoning, there are many convincing object lessons to be seen all about us. In a family of my acquaintance, one member contracted tuberculosis in an unhealthy trade, and lay for some time before being taken. At this time, all the other members of the family seemed in normal health. But, within a couple of years, two more were taken in the same way although the disease was contracted differently from the first case. The remnant of the family was advised to move to other quarters and so far as I have learned, no more

were taken. The sentiment was expressed that leaving the old home, which no doubt was thoroughly filled with the germs of the disease, saved their lives.

Another case which exhibited conditions fully as striking was called to my attention. In a fraternity house, one of the boys contracted tuberculosis, and while sitting by himself, used one of the discarded heat stacks as a spittoon. After his death one after another of these splendid fellows gave up their lives until the fraternity was completely demoralized. After the cause of the scourge was learned and a move was made to other quarters, everything was satisfactory. If time would permit, hundreds of such cases could be cited.

Of all the delicate machinery enclosed in the human body, no part has more effect upon the general health than the incinerator or purifying plant, we call the lungs. When these are not supplied with air of proper quality or amount, or when they are thrown out of service by disease, stagnation ensues.

I am convinced that the author of this paper does not wish us to understand that the wholesale destruction of former precedents and ideals in ventilation, as here specified, is unconditionally recommended by him. Notice the first quotation. The word "baneful" means having poisonous qualities, the state of being harmful or destructive, etc. Also, notice lines: "So far as is definitely known the value of ozone in ventilation is not due to any beneficial effect upon the human economy but to the circumstance that it destroys much that may be objectionable or harmful in 'foul air, etc.'" The whole value of this paper is based upon the fact that ozone has the power to destroy bacteria and harmful substances floating in the air, and, since the author recognizes ozone to be a powerful germicide, he recommends it as an accessory to the modern ventilating system.

I have no criticism to offer upon this view of the subject, except to say that the person not accustomed to inhaling ozone, had better begin with very small amounts and increase the dose gradually. In experimenting with an Ozonator, in my office, I found it necessary to limit its use, because of the influence of the ozone upon the membrane of the nose and throat of those persons regularly employed in the office. In the lecture rooms, however, where there were large room volumes and many people, the room air was freshened and deodorized and no complaints were made by any persons subjected to its influence for

one hour. This paper therefore, as an exponent for the use of ozone in the art of air conditioning, deserves commendation, but it weakens its position in making final and sweeping conclusions concerning those phases of air conditions upon which there is, as yet, so much uncertainty.

My conclusion is merely this: when air conditions within room interiors are become the same as those of the pure outside air, you may expect the best physical health of the people.

Extract read from pamphlet of Prof. F. E. Lee:

"Ozone is a form of oxygen in which three, instead of the usual two, atoms are united in the molecule. It is present in minute quantity in the atmosphere, usually not of cities, but of the country and the sea. Its powerful oxidizing properties and its intemperate advocacy by enthusiastic but unscientific persons have caused it to be hailed popularly as highly beneficial to the human body, not only in ordinary respiration, but in the purification of the air of living rooms, the destruction of bacteria and other organic matters, and the cure of disease. On crisp cool mornings we are fain to enlarge our chests as we step into the open and breathe in deep draughts of this supposedly health-giving gas; to mountain tops and forests we go in search of its renovating properties; and our mail is fat with circulars descriptive of the marvelous benefits of ozone machines, of ozonizers and ozonators. In many offices and homes we find these machines busily at work discharging into the atmosphere their peculiarly odoriferous product. Very recent investigations, however, seem to make it clear that the supposed beneficial powers of ozone as a home companion are creations of the imagination. Two groups of American investigators, Jordan and Carlson in Chicago and Sawyer, Beckwith and Skolfield in Berkeley, have independently carried out each a series of careful experiments on the action of ozone on bacteria, animals and human beings. They find that ozone will indeed kill bacteria exposed in a room, but only when in such concentration that it will kill guinea-pigs first.

There is no evidence for supposing that a quantity of ozone that can be tolerated by man has the least germicidal action.

When present in any considerable quantity in the air ozone is irritating and probably corrosive to the lining membrane of the air passages of the nose, throat and lungs, causing the blood-vessels of this membrane to be excessively dilated and to present

the customary symptoms of "sore throat." It causes headache and drowsiness. The heart, at first accelerated, is later slowed and weakened, and the pressure of the blood in the arteries is unduly lowered. The case for ozone thus seems to narrow down to a supposed beneficial action in destroying or modifying unpleasant odors in the air of a room. When in not too great concentration such odors are, it is true, overcome, though, it is quite probable that their disappearance is due, not to an actual destruction of the odoriferous substance, but partly to a replacement of the disagreeable odor by the odor of ozone and partly to fatigue or anesthesia of the olfactory membrane of the nose. It is very questionable whether this is wise and Jordan and Carlson well say:

It seems to us that this is wrong in principle, and that ozone is being used and will be used as a crutch to bolster up poor ventilating systems. Ozone does not make pure air any more than strong spices make pure food."

Dr. M. W. Franklin: I have read the discussions of my paper by Professor John R. Allen and Professor J. D. Hoffman, and also the extracts from Professor Frederick S. Lee's paper which was read at the request of the President.

Professor Allen questions whether ozone destroys or only masks odors and states that our knowledge of odor is so limited that we probably are not in a position to make any definite statement on this subject. I think I can show that we are justified in stating unequivocally that ozone destroys the odors and does not mask them. In the first place, it may be assumed with reason that we are not gifted with two senses of smell: one for those chemical compounds whose formulae are not definitely known and one for those other chemical compounds whose formulae are definitely known; and, therefore, if the odors of the compounds of known composition are demonstrably destroyed by ozone the disappearance of the odors of unknown composition under similar circumstances is also due to destruction and not "olfactory compensation." Secondly, it may be assumed that if a certain substance gives rise to the sensation of smell; if this sensation of smell disappears on the admixture of ozone with this substance; and if this substance is chemically converted by ozone into an entirely different substance having no odor, then the ozone has destroyed the odor and not the sense of smell. Hence, if it can be shown that in the case of chemical

substances of known composition, ozone destroys the odors, it is entirely reasonable to conclude that the disappearance of odor with ozone in substances whose compositions are not so well known is an indication of destruction and not of "olfactory compensation." Numerous tests which prove destruction of certain odors by ozone are available but I will refer to only the latest, namely, those of Professor J. C. Olsen ("Heating and Ventilating Magazine," July, 1914). Professor Olsen has shown that hydrogen sulphide, ammonia and clove oil (eucaine) are definitely destroyed by ozone and chemically converted into other substances which are without odor. Therefore, I feel justified in stating that where an odor is caused to disappear through the agency of ozone, this odor is destroyed and not masked.

An example of such a chemical reaction is that between quicksilver and ozone. Quicksilver is a bright mobile liquid of great mass and of silvery color and luster. Ozone is an invisible gas which manifests itself to our senses only by its odor. These two substances are practically totally dissimilar. But when they are allowed to come into contact as, e.g., when a stream of ozone passes over a surface of mercury, it is found that the ozone and also the quicksilver disappear and in their place is left a black dense powder, the oxide of mercury. This latter bears no resemblance physically or chemically to the two substances from which it was formed, but is very much like what lamp black would be if it became very much heavier. It is neither liquid, gaseous, silvery, bright, nor invisible and odorous, qualities possessed by one or other of its forbears; in other words, it is no onger mercury nor ozone nor yet a mixture of the two, but a totally different substance. Precisely the same change takes place when ozone combines with hydrogen sulphide. Both these substances are odorous gases but the results of their union are water and sulphur, a colorless liquid and a yellow solid, both without odor or taste.

Furthermore, the methods of the tests which I conducted and to which I have alluded precludes the possibility of "olfactory compensation" being mistaken for odor destruction. The ozone was added to the odors in bottles and the excess ozone destroyed before testing the effect, so it is certain that whatever action the ozone exerted was on the odor and not on the nose. This is especially convincing in view of the fact that it is in accordance with sound, chemical theory and that all evidence which has been cited as supporting the opposite view may easily be

shown to be based on faulty experimental procedure and unsound deduction. There is no reason to believe that although the odors of ammonia and of hydrogen sulphide are destroyed by ozone, the odor of perspiration, for example, is only masked by ozone.

Professor J. D. Hoffman quotes several lines from my paper and takes exception to them. I stated that the only baneful factors in vitiated air are heat, moisture and odors; that the available oxygen is in excess of the demand and that the CO_2 is harmless in concentrations likely to be met with; that the existence of "crowd poisons" is generally discredited; that bacteria as a menace in vitiated air are no longer seriously considered; and from these premises I deduced the conclusion that the modern practice of ventilation is concerned only with the absorption of heat, moisture, and the destruction of odors. In a paper presented at the Fourth International Congress on School Hygiene and published in the "Heating and Ventilating Magazine," V. X., 11, I gave a review of most of the important work that has been done on ventilation up to this time. All of the work which I cited was based upon experimental evidence by some of the best authorities in the world on bacteriology, physiology and sanitation and I can say that so far as such published data might be accepted, the opinions which I above enumerated are demonstrated facts. Whatever belief to the contrary may exist seems to be only in the minds of people who simply hold the opposite view through innate conviction. The opinions of those who have made careful statistical observations and who have experimented in the laboratory seem to be almost without exception in accordance with those views above enumerated. It is evident that facts of a medical and hygienic character are never definitely proven, but in forming an opinion on which to base a conclusion we are safer in accepting the vast preponderance of opinion amongst actual experimenters than in merely following our own unsupported convictions. These views which I have expressed may or may not be correct, but there is much evidence in support of them and virtually nothing to their discredit; therefore, in the absence of better information I am forced to accept them.

Professor Hoffman questioned whether respired air, freed from moisture and odors, and cooled, would be suitable for reinspiration. I would refer him to the recent paper by Doctor T. R. Crowder, Sanitary Expert of the Pullman Company at Chi-

cago, for a most painstaking and scientific dissertation on this subject. According to Doctor Crowder the air might be reinspired any number of times, providing enough fresh air is added to keep the CO_2 vapor tension below the critical point and to supply the oxygen actually consumed. I certainly think that of two men confined in a close space, the one with the acute sense of smell would suffer more than the one in which this sense had been lost. Heat and moisture are most certainly baneful factors in room air when they exist in such quantities as to prevent loss of heat and moisture by the human body and the air is the only method of escape for the heat and moisture produced in the body. Professor Hoffman seems to have understood that I believe that there are "crowd poisons" in air but I endeavored to point out that I do not hold this view, as will be evident on carefully reading my paper.

Regarding the existence of bacteria in expired air, I would refer to Professor Chapin's classic work on this subject, (Modes and Sources of Infection). Professor Chapin is perhaps the foremost authority in America on the subject of epidemiology and his view in common with many other eminent authorities is that there is no air-born infection.

With respect to the use of a very small amount of ozone in ventilation, I fully agree with Professor Hoffman, and our greatest difficulty has been in persuading people to use a sufficiently small amount to get results.

Regarding the quotation from Professor Frederick S. Lee's paper, it can be said that Professor Lee's opinion is frankly based on the work of the authorities whom he quotes and not on any observations or studies of his own. The experiments which he cites showed that ozone, strong enough to produce sterility in cultures, would prove extremely injurious to occupants living in the room, such as guinea-pigs. This is true, but, as I have mentioned in my paper, no known method of room disinfection can be practiced in the presence of occupants. Furthermore, Jordan and Carlson's paper and those of Professor Olsen, myself and numerous other observers have shown that ozone most certainly will reduce the bacterial content of the air, even when in such small quantities as to be easily and comfortably respirable.

The conclusions with respect to the action upon the heart and nervous system that Professor Lee quotes from Jordan and

Carlson are entirely negatived by their own statement that all the effects are due primarily to the local corrosive action of the ozone on the mucuous membranes of the lungs. Translated into lay language, this is a confession that ozone has no specific poisonous action whatever, but that when it is used strong enough to inflame and corrode the linings of the lungs there will result other secondary symptoms precisely as would be the case if the irritation had been caused in the first place by sulphurous acid, hot steam, or even pure oxygen. Regarding his opinion as to whether ozone should be used to destroy odors because of the question as to whether ozone destroys or only masks odors, I think that I have already disposed of this question.

CCCLIV.

THE HEATING INDUSTRY IN CANADA.

BY NORMAN A. HILL, MEMBER

In response to a request from our Secretary, and several reminders from our President, I beg leave to present to you a short paper essentially nontechnical on the subject of the Heating Industry in Canada. In this paper the following seven topics are touched upon briefly:—

1. As to peculiarities of trade practice as seen from the viewpoint of a United States citizen resident in Canada;
2. As to prevalent Canadian practices in steam, vapor and hot water heating;
3. Brief comments on some interesting installations in the City of Toronto;
4. Contract practice as in vogue in Toronto;
5. Compulsory ventilation laws existent and pending;
6. Air conditioning—the lack of it, and the endeavor to promote it in Canada;
7. Opportunities in Canada for the Manufacturer of Heating and Ventilating apparatus, and a general resumé of this paper.

One of the things that struck me as peculiar when I became a resident of this city and entered into private practice, (as a Consulting Engineer, specializing in Industrial Engineering work), over two years ago, was the fact that the large plumbing contractors in this city, and throughout Canada generally do, not only heating and ventilating, but electric wiring for both light and power, and in many cases automatic sprinkler equipment, and vacuum cleaning installations as well. This strikes a "Yankee" Engineer as decidedly odd, (all of us former residents of the United States are called "Yankees" whether we come from New England or Texas), and speaking from eight years' experience in the middle Atlantic States, I have found it very unusual for the average plumbing

contractor to undertake electric work, and automatic sprinkler equipment, until I moved to Canada.

It would seem in accordance with the best local practice to use one pipe steam heating where low cost of installation is considered, for cheap residence, apartments, stores, and business buildings: For better class work; such as is found in the smaller manufactories, warehouses, office buildings, hotels, clubs, the best local practice seems to be for either vacuum, steam or vapor heating, using low pressure boilers. As a matter of fact high pressure boilers are not much used in Toronto, except where steam at high pressure is absolutely necessary; this for the reason that electric energy from the hydro plants may be obtained by large consumers at or about 1 cent per kilowatt delivered.

Hot water heating is very popular for the better class of residences and apartment house work, and strange to say it is still considered good practice locally to use twin connections, that is both supply and return connections being made at the same end of the radiator: By this I mean it is considered good practice by the Canadian Heating Contractors, although I do not know of any of the local Consulting Engineers, (who are practically all former United States citizens) who approve this twin connection arrangement with the old fashioned twin headers at the boilers, and separate feeders and returns run therefrom to each set of risers. Where work is laid out by one of our Consulting Engineers it is in accordance with the best American practice, and a tendency, as shown in the open tank system of gravity hot water heating, is to use rather small sizes and high velocity in order to enable the operator to warm a house up quickly in the morning after the system has been allowed to cool over night. In connection with local hot water heating it is interesting to note that forced hot water circulation is rather a new thing here, but fast coming into acceptance; as evidence of this fact, the following large installations are of this type:—

The Toronto Central Technical School,
Bishop Strachan School,
Wellesley Hospital,
New Union Station,

and the new manufactory of the National Cash Register Company. In addition to the above mentioned interesting installations of forced hot water heating, many large buildings now in progress

of construction in Toronto are being furnished with vacuum or vapor steam heating, as for example:—

The Toronto General Hospital,
The Sick Children's Hospital,
The Dominion Bank Office Building, (10 stories)
The Canadian Pacific Building, (18 stores)
The Royal Bank Office Building, (20 stories)
The Municipal Registry Office, (5 stories)

also the new factory of the United Drug Company, Limited, and the new factory and warehouse of the Ford Motor Car Company.

It may interest you to know that in the city of Toronto, the gross cost of construction work last year was in excess of twenty-seven million dollars, and judging from building permits already issued, the gross construction investments for 1914 in Toronto will exceed thirty million dollars. These are really astonishing figures, when one considers that this city has a population of approximately 500,000 people, while Baltimore with about 600,000 spends for construction work less than half the amount which is spent in Toronto or Montreal.

As to local contracting practice, it is much the same here as any place else in Eastern Canada, that is to say, there is a decided tendency to let work by separate trades, rather than by general contract; as is the practice in the United States, wherever the operation is of considerable size. This custom, of course, makes a great deal more work for the architects or engineers than is necessary where a general contractor is employed, but may be better for the heating industry generally, in that the heating contractors are not at the mercy of unscrupulous builders, who having once closed the contract "shop" the various sub-contracts for their own personal profit, regardless of the best interests of the owner, or the sub-contractors, whose tenders they used in making up their estimates. There is, however, a serious objection to this practice of letting the work on a large building by separate trades, in that the average architect, or engineer seems unable to prevent the overlapping of work between contractors, and the omission of certain work due to the division of responsibility.

Now as to time and material work in Canada, it was interesting to me to find that most of it was done on a cost plus 25 per cent. basis, and generally speaking it would seem that contractors for heating and ventilating do business in Canada upon a larger margin of profit than is customary in the middle Atlantic States.

This has resulted, together with the duties paid on imported materials, in increasing the cost of heating and ventilating work here on an average of from 20 to 30 per cent. more per unit than costs in Philadelphia, for example.

Laws for compulsory ventilation of factories are fairly comprehensive in the Province of Ontario now, and in this city the Medical Health Officer is at present requiring the owners of moving picture theatres, and other public places of amusement to provide better ventilation, but there is really no satisfactory standard, or established practice for providing adequate ventilation for public buildings in this city, or elsewhere in the Province of Ontario, and I understand that conditions are similarly unsatisfactory as to ventilating laws, throughout Canada.

The local Society of Heating and Ventilating Engineers, which has a membership of over forty, is endeavoring to obtain legislation along the lines of adequate compulsory ventilation for all public buildings and factories of whatever nature.

Air conditioning as it is generally known, including humidity control, and air purification, has made little progress in Canada, except in the best class of public school work, colleges, and banking houses, but I am glad to say there is a decided movement on foot to make proper air conditioning a requirement by law in all public school houses in the city of Toronto.

Automatic temperature regulation also, has not made nearly the progress it has in the Eastern United States; temperature control installations being pretty well confined, so far, in Canada, to the best class of hotels, office buildings, banking houses and private schools.

The greatest opportunity to-day in Canada, in the heating industry, to my mind, is that existing for the manufacturer of heating specialties, that is to say, the concern which is in a position to open up a branch factory in Canada, and manufacture their product and place it upon the market, as a "made in Canada" article, for example: A great many of the steam specialties used in the better class of heating installations here, are imported from the United States, and I believe that a manufacturer with a complete line of heating specialty apparatus, including: vacuum, and vapor valves, angle, gate and radiator valves, pressure control and reducing valves, boiler fittings, gauges, temperature regulators, air valves, floor and ceiling plates, and the miscellaneous specialties required for steam, vapor and hot water heating would have an excellent

field; particularly, if in connection with the line, he would manufacture good reliable elevators, fire vacuums, and boiler feed pumps.

The field for contracting work, to my mind, is not so good for the United States concern contemplating a branch office in Eastern Canada. Nor is there the opportunity now existing, that there was some three or four years ago, for the new consulting heating engineer in this field. However, this huge country (larger in actual area than the United States) has room for all, and from my own experience has also a warm welcome for all, who peaceably invade it from the United States, provided the invader, in making his living here, can and does create or do something worth while; for Eastern Canada is already over populated with incompetents, but there is an existing and increasing demand for the really competent individual in almost any line of business, including every branch of the heating industry.

DISCUSSION

Mr. James H. Davis: I would like to ask if the Toronto General Hospital doesn't use forced hot water for the direct radiation, and steam for the blast? It is the first job of its kind that I ever saw laid out in that way.

Mr. Dwight D. Kimball: I feel very much interested in the paragraph relating to the general contract and separate contracts. I am glad to know that the tendency exists there to let by separate contracts. To my mind there is no justification for any other method of doing it. I think that in three states in the East there are now laws requiring separate contracts on all state and, in some cases, county and city work. I hope that such legislation will spread to the remaining states of the Union.

I cannot see for the life of me where it makes more work for the architect and engineer. I am doing several jobs which were let with general contract. From the standpoint of the engineer it imposes a lamentable amount of unnecessary work. In certain cases matters of difference have to be carried back and forth between the general contractor, sub-contractor, the architect, etc., and by the time the whole matter has been passed backward and forward days, weeks and even months may elapse before the final round-up is made, and in some cases it is never completed.

Also the poor engineer finds difficulty in determining the basis of his fee. If he is collecting on a commission basis he is lucky if he gets paid in any reasonable time. It needlessly increases the amount of correspondence and detail work. I have not seen a single advantage in the general contract in any respect. It seems to me that the engineer, contractor, and architect are sadly overloaded with work because of the routine.

Within the past three months I have heard of one contractor who said that he would not put a bid in under a general contractor if he never got a contract; that he preferred to contract with the owner direct rather than with the general contractor, and that he would make a reduction of three per cent. in his bid, (which amounted to something like $60,000), if he could put it in on the basis of separate contracts. He said he would rather do that and receive his money promptly than subject himself to the general contractor.

In another case, before the contracts were let, the contractor made a statement to the architect that he would be glad to make a bid five per cent. less to the owner than his original bid to the general contractor, because he realized that he would probably have to cut that much off before he got the job. The owner pays that five per cent. and the general contractor pockets it. I do not see where there is any advantage to the owner in that.

Few people realize the amount of injustice to which sub-contractors are subjected by general contractors.

True, similar injustice is done to the sub-contractors of the heating, lighting and plumbing contractors but this may be largely prevented by requiring these contractors to name their sub-contractors and materials in their proposals and holding them to the specifications and their statements in their proposal.

As to the overlapping of certain work, or omission of certain work, it seems to me that that is a very serious reflection on intelligent architects and engineers, to say that they are not capable of preventing this. I have been going through it for eighteen years. There is no reason for either overlapping or omission if simple ordinary care is used in detail work. It is to prevent those things that the owner employs the architect or engineer, and when so employed they should be capable of doing what they are paid for. I think we would all be glad if we never heard of a general contract.

Mr. Theo. Weinshank: In the same line just referred to by Mr. Kimball, I will say that before our noble friend, T. J. Waters, of Chicago, died, he told me that during his administration he had saved the city of Chicago nearly $12,000,000 by not having general contractors on any of the buildings. He let the brick work to one man, the stone work to another man, the carpenter work to another man, etc., and the result was that he had probably fifteen or twenty contracts. For the heating and ventilating he would let the blowers to one manufacturer, the galvanized iron to another man, etc.; but he had a capable man as superintendent on the building to look after the work as it progressed. The five per cent. or ten per cent. which the general contractor usually adds to the sub-contracts he saved to the city of Chicago, and it amounted to $12,000,000.

I know of a case in a certain city where a general contractor used to get figures from sub-contractors, and after receiving the contract, he used what contractors call "paddle" on sub-contractor's figures. In other words, he would go to one sub-contractor and ask him to cut a certain amount from his original bid, and then go to another contractor and state that "A" has cut his figure and "if you will cut another hundred" he would give him the contract. Keeping this up he would finally get someone to figure low with him, with the idea of putting in the cheapest material possible.

This certain contractor kept this up until such a time when the contractors got together and quoted him on a prospective contract, very low figures, and after he received the contract, they all withdrew their quotation, thus leaving him with about a $35,000 loss on the contract.

This contractor is out of business to-day—and for all time to come.

Referring to the case where Mr. Hill claimed that there seems to be a prevailing practice for the heating and ventilating contractor to add wiring, plumbing, etc., I may say this, that the English influence is still there, because that is done all through England, the heating engineer takes the contract for the heating, plumbing, wiring, and everything in connection with the mechanical work on the building. Canada being so close to us, I hope in a short time that they will begin to learn that the more sub-contractors there are on the job and the more the contract is split up, the better it is for the owner, the better it

is for the contractor, and the better it is for the engineer, as well as reducing the cost of building.

Mr. Dwight D. Kimball: I do not want my remarks to carry beyond their intent. Some may say, if you are going to take separate bids for the plumbing, the lighting and the heating, why not take them on the brick work, carpenter work, etc.? I think that is going too far. The heating, lighting and plumbing are essentially separate things and can be well divorced without interfering with the work on the building; in other words, they do not affect the building as a structure, but they comprise rather the mechanical equipment. So far as heating, lighting and plumbing going together, it seems to me that this is growing to be the practice in this country. There are a good many contractors taking it up.

Mr. Norman A. Hill: As I understand it, Mr. Kimball disagrees with my statement that the contracts for building construction and equipment should not be by separate trades because it puts much more work on the architects and engineers. While I may be wrong in that matter I am not convinced that I am. I was a contractor for over six years, but for the last four years have been on the other side of the fence in consulting engineering. Our company now handles the architecture as well as the engineering of industrial buildings. We have found on large work that it is more economical (from possibly a selfish viewpoint,—that of the engineer and architect) to let the strictly structural or construction trades, the shell of the building, so far as possible to the least number of sub-contractors providing that you get men of known standing. We let equipment work generally to any one of the several large concerns in Toronto who do all work in mechanical lines and do it well. They all do good electrical work, good sprinkler work, good heating, good plumbing, etc. In other words, a general contract for building and a separate general contract for equipment.

Speaking of the Canadian practice, the business methods there are quite different from those of the "live wire" plumbing and heating contractors that you find here. It is an established fact that with you the work of the architect and engineer is less than with us because the number of sub-contractors is smaller—provided that in giving a general contract for all trades you give it to a responsible building concern. I cannot see that by general contracting in that way the amount of work for the architect or engineer can be greater; surely there is something saved in not

having to handle twelve or fifteen different sub-contracts. It seems to me, Mr. Kimball, there is not very much room for argument on that.

Now as to the question of the competency of the architect and engineer to prevent overlapping, that question is pertinent to Canada particularly; we have a peculiar condition there as to architecture which is easily understood when you realize that in Toronto 86 per cent. of the people are of either direct British descent or else the first generation are English, Scotch, Irish, or directly descended from those races. Therefore the local tone in architecture and engineering is essentially British, and their methods are not as much up to date as they should be, there is no question about that; and the architects there, according to my own experience in the last two years, have shown a preference to sub-letting to the different trades. I think that possibly is to the advantage of the separate trade contractor rather than to the interest of the Owner, for there is no doubt about it that when work is handled by the architects that we have in Canada and by the engineers that we have in Canada, this business of having everything covered by separate trade contracts, instead of one or two general contracts, results in a multiplication of extra charges for the Owner. That is one big point that I wanted to bring out.

CCCLV.

HYDRO-ELECTRIC POWER COMPARED WITH STEAM

BY REGINALD PELHAM BOLTON, MEMBER

The heating engineer is naturally concerned in all matters connected with the utilization of heat or the production of energy. The work of the profession has centred about the generation of steam, and the use of coal is the basis of the art at the present day, notwithstanding the advances of utilization of other forms of stored energy such as oil, gas and peat.

Our profession cannot afford to ignore any developments bearing upon or affecting this great subject, which lies at the base of the habitable use of a large part of our own country. The heating engineer may well feel that in the development of his art, he is dealing with the fundamental necessity of our nation.

The spread of general information has of late years attracted public attention to such wide subjects as the fuel resources of the nation, and the present dependence of the industries, the welfare as well as the comfort, and even the possible existence of a great part of our future population upon its available supply. These speculations have formed a large element in discussions upon the subject of conservation of national natural resources, which has widened into the advocacy of the development of water powers as a substitute for the use of fuel. This process has been in existence since ancient times, but has been restricted in its application to its own locality, until, by the developments of science, the transformation of hydraulic power into electrical energy, and the transmission of the latter over extended distances, has become practicable. and has brought the developed and transmitted energy into sharp contrast, and commercial competition, with the forces latent in fuels. At this point, therefore, the heating engineer becomes directly con-

cerned in the progress of the movement, and we may with advantage take up the subject and analyze the process from our own practical point of outlook.

An Engineer's natural enquiry is, first, what is the principle of conservation, and in what way is it applicable to the application of water powers to electrical power development, and wherein is conservation of fuel effected thereby.

Real conservation consists in a reduction of any unnecessary use or wastage, of any natural supply of materials. It does not consist in the substitution of some other process or use of some other material to the abandonment of a formerly utilized material. The most economic and least expensive method is that which effects a conservation of a material.

The high-sounding title of conservation is really nothing more than mere economy or thrift, terms which are as old as our language.

The principle of conservation is, however, truly applicable only to this process, and is not found in an abandonment of the use of resources readily at our command, in favor of some other method of the production of energy, especially if the latter be accompanied by unnecessary expense in investment or operation.

The engineer who effects increased results for the consumption of a given amount of fuel, is a true conservationist. The process has been in quiet progress for many years in the art of power production, during the agitation of conservation.

The amount of fuel used for the production of a kilowatt of energy in modern plants has been undergoing a continuous reduction, as a result of the greater concentration of the production, and the resulting use of better proportioned machinery.

The actual conservation which has been effected by the more economic use of fuel in electric power production far exceeds any results that could have been attained by the use of all the water powers in present service. In one of our largest cities, during the ten years from 1903 to 1912 inclusive, a total of 3,782 millions of kilowatt hours was generated by the destruction of 6,284,000 tons of coal. In the year 1903, the rate of fuel consumption per kilowatt hour generated was 6.87 pounds. At the end of ten years, this rate had been reduced partly by improvements, and partly by the larger units operated, as well as the improved load factor resulting from combining the demands of more consumers, to

less than three pounds of coal per kilowatt hour, or one half the rate obtaining in 1903.

The consumption of fuel during the ten year period, if it had been maintained at the rate prevailing in 1903, would have involved the consumption of 13 million tons. There was saved or conserved, by the process of improvement, more than fifty per cent. The use of very large boilers, used at high rate of output, combined with large generators, has reduced the coal consumption per kilowatt of energy for an hour, to less than two pounds weight of bituminous coal, in the Central Station of the Detroit Edison Company.

The centralization of heating plants tends in the same direction. Undue excitement has been engendered by Conservation enthusiasts over the possible exhaustion of our coal supplies. There are other sources of heat, of even greater extent which, as time proceeds, may be rendered commercially and economically available. It may very likely be the case that, for the purposes of heating only, future generations may abandon the use of coal and substitute less valuable materials such as lignite or peat, leaving the supply of more efficient material for the production of power for profitable purposes.

Our present demand for coal for all purposes is about 575 millions of tons per annum.

The commercial value of the material is mainly composed of the cost of labor and machinery for its extraction and of transportation from its source to its point of usage. Our entire system of railroads and our vast advantages in water transportation are contributory to the economical distribution of coal. In low cost of output, we take the lead in the world with an extraction of 600 tons per employe per annum as against 275 tons per employe in the United Kingdom.

The latest official guess at our available coal supply places it at six hundred thousand millions of tons. This may be geologically reliable or not, but it will depend upon the proportion of the total which is assumed to be won from the seams. At Hazleton, Pennsylvania, abandoned seams of anthracite are being worked by stripping off the entire superincumbent soil and rock and instead of an expected forty per cent., it has been found that nearer sixty per cent. had been abandoned in the workings.

At our present rate of fuel extraction, the estimate affords a store that will last a thousand years more or less, probably more,

since every improvement in economy will reduce the rate of usage for any given work.

Lignite is available in still larger quantities. In seven of our western states alone, there is estimated to be more than a million million tons, or nearly two thousand years of the annual rate of coal output for 1912.

The value of all fuel is not only in its heat capacity, which is present to a greater or less extent in vast stores of other materials, as well as in the rays of sunlight, but in its commercial cost. It is only in its present wide use to-day because of its commercial advantage over other forms of heat.

If the commercial utilization of sunlight were practicable, it would be because the total cost is less than that of coal and the same remarks apply to the use of wind or water powers.

The cost of the Sun-heating plant at Meadi, in Egypt, has been only $170 per horsepower, which compares very favorably with that of most water-power developments.

There is nothing, therefore, inherently to the advantage of water power developments over other methods of power production, and no greater advantage to the world by their use nor less by their disuse, than by the present lack of utilization of the sun's rays or the wind's movements.

The substitution of water power for steam power does not add an equivalent amount of fuel to the supplies of the nation. Water power which is now available will be just as available in the far future, and use can be made of it at any time, whenever its operation proves economically desirable. That period or opportunity depends upon the relative cost of coal, and the utilization of water power is clearly dependent upon the price of fuel, at the point of distribution of heat or energy.

Since water powers are continuous, and coal or other fuel supplies are not, the only effect of utilizing the power of water at the present time, is to delay, to that extent, the consumption of an equivalent amount of the available fuel supply. There is no eventual saving in fuel whatever, since the coal will be used either now or in the future, and water power may be used at any time between now and the end of the estimated life of the coal supply. Thus, a water power simply renders available, at some future period, a certain proportion of the fuel which might otherwise have been consumed at a prior date.

There is evidently, therefore, no true conservation effected by

the use of water power as a substitute for coal, but only a delay in the eventual use of the fuel. But the present supply of fuel is so accessible that it is more economical to use fuel in most localities than it is to develop and use available water powers. Nothing, therefore, can be gained from an economic standpoint, or for the enrichment of the nation, by any premature use of water power which involves excessive cost. Wherever water power has been developed to advantage, it has been because fuel was either unavailable or was relatively expensive in the region served by the water power, as in the partly undeveloped regions of the west.

The statement that water power may not be as economical a source of energy as steam power, will doubtless constitute a disappointment and perhaps come as a sharp surprise to many persons, whose ideas on the subject have been developed merely by consideration of the apparently ready availability of energy in the form of falling water. Official statements have been widely published as to the large quantities of power existing in water falls and rapids in this country. These statements always fail to convey the necessary information that the power is stated in terms of *water* horsepower, which is very different to the unit of generated energy.

It is officially asserted that there is in use in this country, a force of six million water horsepower. Most of this power is situated in districts remote from the place of commercial usage. It must be transformed from water horsepower into electrical horsepower, transmitted over certain distances, and finally distributed to the consumers. Any comparison as to its commercial or relative value as compared with fuel must be made upon the basis of the distributed and utilized energy which could be generated upon the spot by the use of fuel.

The losses due to the process of generating electricity by water power are considerable: They consist in losses of head due to water shortage, loss in draft tubes, losses due to inefficiency of turbines, and varying heads and loads, dynamic and frictional losses in operating generators, losses due to transformation and transmission of electricity.

In the case of the large plant of the City of Seattle, tests were made, the result of which showed that of the dynamic force available in the water at the penstock, only 50 per cent. is represented by the transmitted energy in the form of electricity. Quoting from the annual report for 1911. "This study brought out the important

fact that in determining the amount of power in a reservoir, the efficiency ordinarily assumed for the power units is much too high and misleading." While the combined efficiency of generator and wheel was found, in the case of the 5,000 kilowatt units to be 76.7 per cent., and in the case of the 1500 kw. units 69.9 per cent.; the all-day efficiency of the plant for 1911 was 56.7 per cent. Including current for excitation, the all-day efficiency was 55.7 per cent.

The losses are tabulated as follows:

Generating system—Per cent. of total energy at penstock lost:	
Penstocks	2.31
Water wheels	37.89
Generators	3.78
Excitations	1.26
Station lights and control	0.33
Loss of station output, of penstock input	45.57
Transmission System:	
Step-up	2.14
Transmission	0.72
Step-down	1.72
Loss of transmission system in per cent. of penstock	4.58
Total loss	50.15
Net energy delivered, of energy at penstock	=49.85

Back of these fundamental reductions in the value of water power, lie further burdens of cost of construction as compared with steam-power plants, which are increased by the cost of constructing, and expenses of operating, transmission lines. The statement has recently been made by Mr. Lucius B. Andrus, that, owing to the usual conditions prevailing around our water powers, it may be assumed that water power developments will cost about $250 per kilowatt, the fixed charges on which, therefore, would amount to about $25.00 per year per kilowatt of maximum capacity. The cost of transmission systems will add from $100 per kilowatt upwards to this initial cost of development.

The Niagara transmission system of the Hydro-Electric Power Commission of Ontario has cost, up to October, 1913, $128 per kilowatt of maximum demand, and $60 additional per kilowatt, for transformation apparatus and transformer stations, making a

total of $188 per kilowatt, the fixed charges on which are about $15 per kilowatt of maximum demand.

Carrying such initial burdens, hydro-created energy must meet, at the point of its distribution, competition established by any well-proportioned and economically operated steam system. Modern steam generating power plants have been constructed recently at a cost of $50 per kilowatt of installed capacity. The fixed charges are thus less than a third of the cost of the transmission system alone, such as that of the Ontario Government.

Mr. John C. Parker of the Rochester Railway & Light Company, states that a modern steam-generating station of 20,000 kilowatts capacity, with 10,000 kilowatts added for reserve, can generate energy at a cost of 0.5 of a cent. per kilowatt hour, inclusive of interest, and depreciation on its cost, and all operating expenditures.

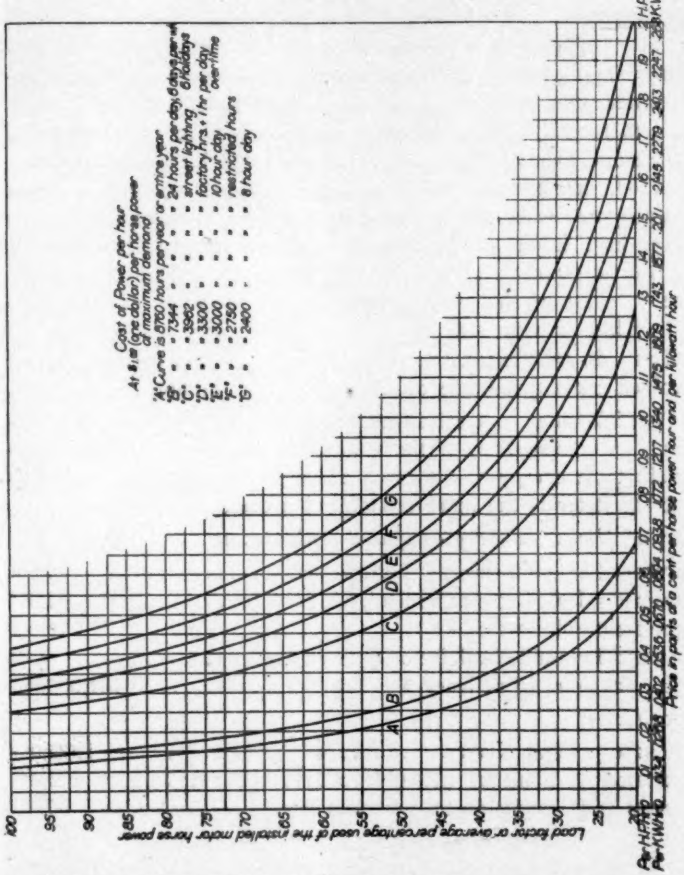
The costs of hydro-electric energy in 1912 in several cities of our State, were as follows:

Rome	1.140 cents per kw. hour
Albany	0.907 cents per kw. hour
Syracuse	0.646 cents per kw. hour
Rochester	0.520 cents per kw. hour

The cost of steam-produced energy in the latter city was:

Fuel	0.170
Labor	0.126
Supplies	0.026
Repairs, etc.	0.022
	0.344

The cost of the service of hydro-electric energy often looks attractive if the effect of purchasing energy by the annual horsepower rate is not fully appreciated. Appearance of cheapness is given to a service of this character when a consumer contracts for a supply of energy at a rate of say $25 per annual electric horsepower. Under the terms of such an arrangement, the consumer may use this horsepower at full capacity day and night, the whole year round. But under practical circumstances of industrial operations, it cannot be utilized for more than the usual hours of factory operation, or 3,000 out of 8,760 hours. Moreover, the conditions of all industrial operations are such that the full connected load cannot be utilized at all times, and the percentage of use of the maximum or connected capacity will vary down to as low an average as 6 per cent. in certain industries.



This diagram shows the unit price of an annual horsepower at various numbers of hours of use, and at any load factor on the basis of one dollar per annual horsepower. The price per horsepower hour, or per kilowatt hour, which is read upon the horizontal scales at the base of the diagram, should be multiplied by the number of dollars paid per annual horsepower. As an instance, the purchase of an annual horsepower at $25 used for 3,000 hours, on a 33 per cent. average use or load factor, is equivalent to a price of 3 4/10 cents per kilowatt hour of energy actually used. This price is no better than could be obtained from many comparatively ill-equipped steam power systems.

Since the basis of comparison and competition is the utilized energy at the place where it is required, a steam plant developing energy as and when it is wanted, and meeting, without excessive losses, the fluctuations in demand, is at a considerable advantage, compared with a hydro-electric system in which the force is at all times available in full quantity and can only be varied by changing

the number of units in operation. Still, it may appear to be, to those unacquainted with steam economies, a strange assertion that energy supplied from Niagara may not be as economical as steam-generated energy within a distance of twenty miles of the Falls.

Facts recently published by the Public Service Commission of the Second District, of the State of New York, in a recent case, No. 169, demonstrate that this is actually the case. A contract was proposed to be made for the purchase from one of the existing power installations at Niagara, of a minimum quantity of 46,000 electric horsepower, at a price of $12.50 per annual horsepower. The purchase of this energy involved an acquisition of franchises and rights of way, the cost of which ran into about a million dollars. In addition, a transmission line and transformer stations involved the expenditure of about one half million dollars.

The following comparison of the elements of cost in this proposal, as compared with the generation of the same amount of distributable energy at the place of usage by steam power, shows that the latter is the more economical process of the two:

Cost of Niagara energy compared with steam:

Purchased amount—electric horsepower	46,000
Assumed sales, of connected load, e.h.p.	63,000
Equivalent in kilowatts, kw	47,000
Assumed favorable load factor, per cent	33
Output at point of delivery, kw. hrs	137,000,000
Hydro-Electric:	
Purchase price at Niagara	$575,000
Operation to point of delivery	115,000
Interest and charges on transmission line	50,000
Cost	$740,000
Steam:	
137,000,000 kw. hours at 0.5 cent	=$685,000
Steam is cheaper by, per annum	55,000

Perhaps the most interesting feature in the development of hydro-electric processes has been the gradual dependence of such systems upon steam-power plants as reserve and security against break-downs of their generating and transmission systems. When every precaution has been taken in connection with water-power development, or a transmission system, experience has shown that failure by ice or storm or flood must always be anticipated, and a necessary provision is required in the form of steam power reserve

plants, the cost of which becomes an additional burden upon the hydro-electric development.

The author of "Hydro-Electric Practice" says, "A very good and learned friend of mine remarked that he 'could always find a hydro-electric plant by looking for a smokestack near a river,'" and Dr. Charles P. Steinmetz writes, "the possibility of a breakdown of a transmission line requires a steam reserve." When security and continuity of service are of value, steam power must be considered superior to water.

The most interesting demonstration of this fact has been very recently made in the report of the Commissioners of the Hydro-Electric System of the City of Toronto. This body, after only a few years of operation, has come to the conclusion that a million dollars, which is a twenty per cent. additional capital investment, must be spent upon the construction of a steam reserve plant in that city. Another striking illustration of the same process is found in the present construction of a steam generating station of 88,000 horsepower capacity by the Dominion Power & Transmission Company, of Hamilton, Ontario, only forty miles away from Niagara, and in a city served by its own hydro-electric system, as well as by that of the competing system of the Ontario Government.

There is therefore comparatively little value in the broad assumptions of conservationists on the subject of "white coal," "harnessed energy" and "conservation" of water powers.

The value of water powers is restricted to the equivalent cost of production by other sources of energy.

Their non-utilization is no more of a loss to the world than our present lack of use of the heat of the sun, the movement of the wind, or the rise and fall of the tides.

One of the wild statements periodically issued by the political authorities of Ontario recently asserted that the Province would soon be utilizing half a million hydro-electric horsepower, and that this would result in an annual saving of 7½ million dollars now paid for coal.

The present use of the Government Niagara System is less than 40,000 horsepower of maximum demand, so that the eventual result so anticipated would seem to be far distant, and meantime, steam power is beginning to be recognized as a necessary adjunct to a substantial extent. Use must be made of the reserve steam plant, or otherwise it becomes a heavy burden or cost. Thus, the cost

of hydro-energy is increased in three cities by the operation of necessary steam reserve plants by from 21 per cent. to 64 per cent. It must evidently pay to utilize a reserve to its best capacity, and maintain it always in fully serviceable condition. The extent to which this should be done is a problem which has so far received little attention. In this direction, the steam engineer has a field for future operation.

There is one feature of cost in which hydro-electric developments have a distinct advantage over steam stations;—located as they are usually in unsettled districts, they are not burdened with the taxation which falls upon the plant located in a crowded community. It is a fact that in the great cities taxation is greater than the cost of coal, and is nearly twice what is paid for station labor. But even with this handicap, steam is cheaper. It is the money required on investments which is the controlling element in the costs of energy, and these are always greater in the hydro than in the steam plant. Mr. Samuel Insull recently said, "It is not the price of coal, nor even the price of labor, it is the price of money that 'governs'."

Every possible source of argument has been brought to bear, whether suitable or unsuitable, upon the public mind, in order to influence public opinion in favor of schemes for the development at public expense of water powers. Perhaps the most ingenious, because the most distorted, has been the argument of conservation, which, upon examination, is found to have little value.

If similar publicity could be secured for the chastening reflections accompanying exact figures and observations of comparative costs, and of the possibilities of economic fuel utilization, as that which is given to the assumptions of uninformed enthusiasts, it would doubtless change the general view of "conservation" as applied to the white coal, the harnessed energy, the glittering dew drops and the conservation of fuel by water power.

When such modifying considerations are understood the public will doubtless exercise great caution in accepting suggestions for the expenditure of their money on the vacillating waters of falls, rivers and rapids, where coal stands ready at less cost to afford cheaper and better service.

And once it is fully understood that there is no conservation at all in the postponement of the use of fuel by another power which will be just as readily available later on as now, it is probable that much of the fanciful generalities as to glistening diamonds

and free power will fail to attract the attention of serious minded people.

Water powers have their use, limited to their own locality, and restricted in value elsewhere by competing forms of other natural forces.

Their use has been somewhat widened by their adaptation to electric energy and its transmissible capabilities, but this very fact has brought the system into sharp conflict with its competitors on the ground occupied by the latter.

As in the past, so at present, Coal is King, and its dethronement will not be effected by water power, but more likely by sun power. Neither development, however, has an incentive so long as supply, transportation, and methods of its use keep pace with demand. With oil, lignite, and peat as its allies, the use of fuels will increase far beyond the point where every water power on the continent combined could seriously affect the situation.

The way of conservation does not lie in the path of water-power developments, but in the direction in which we, as engineers, are specially engaged, the reduction of wastage, the promotion of economy, the spread of the habit of thrift, and the improvement of the art of effective utilization of the fuels which nature has so abundantly placed at our command.

DISCUSSION

President Lewis: I think Mr. Bolton has shown a creditable spirit in contributing this very interesting paper. I hope there will be a full discussion.

Norman A. Hill: This paper is particularly interesting to me, because Mr. Bolton has referred to the hydro-electric development up in Ontario. I am pleased to hear what he has to say about that, for the reason that I am living in Toronto and I get in the morning a paper that is known as the "Liberal" paper, and in the evening I get the other, the "Conservative" paper. I take both party papers so as to get a look at both sides of the political controversy with regard to the Hydro Electric Commission and its developments.

The hydro-electric scheme has been fostered and carried along pretty well by the present government, the Conservatives, under the Honorable Sir Adam Beck, who was recently knighted. Hydro is a pet scheme of the present Ontario Government, so that it is being supported by all the administration papers, and

criticised by the opposing party, which is the one that Sir Wilfred Laurier was the Premier of for so many years. They, the Liberals, of course, take every opportunity to slam the Hydro Electric Commission, so that we get some very interesting discussions in the Toronto papers on this matter; and in connection with it, on the desirability and necessity of a steam reserve plant: The Commission has reported that it is desirable and necessary to erect such a plant; but, it is a question whether the necessary legislation can be obtained to raise the funds, because any outlay for that reserve steam plant, so far as the City of Toronto is concerned, has to be approved by the taxpayers, and will have to be submitted at the regular elections. There is a good deal of opposition to the steam reserve plant even on the part of those people who heartily approve of the hydro development as a scheme, and I have been interested to find out if there was any reason other than politics for the so common objection to this reserve plant, because I felt that it was quite natural for the Government party perhaps to back up the hydro scheme and say, "Yes, we want the steam reserve plant, if necessary." And the average person looking at the matter from a non-partisan viewpoint can see that it is necessary, because we have had some very bad breaks, in the winter time especially, when the city lighting has been out of commission sometimes for hours. Fortunately the supply from the private corporation has not been off at the same time that the municipal supply has, for in a city of any size it is a very serious thing when the electric lights go out, or when none of the street cars can move. I myself have had to walk a mile or so up on the hill where I live, and thousands of people have been in the same plight; but the Toronto Hydro has been very fortunate in not having many breaks of very long continuance. A great many of the people who are not strong in their party affiliations on one side or the other, Yankee manufacturers, housewives and others, would like to see a steam reserve plant, for in that case they would feel reasonably safe in being supplied with electric light and power at all times.

With these things in mind I have tried to find out why there seemed to be a general sentiment against the steam reserve plant, in spite of the fact that the people who are looking after their own comfort will feel assured that this reserve plant insures their comfort and convenience. My own conclusions in the matter are partly confirmed by the remark that Mr. Bolton quotes from Mr. Samuel Insull, who he states recently said: "'It is not the

price of coal, nor even the price of labor, it is the price of money that governs.' " I think probably that is part of the answer. It has been sometimes said that Canada generally has over-borrowed, but I question whether that is correct. I do not think it is true. But anyway, they have borrowed a great deal of money and have been putting it in public improvements of all sorts; in fact, anticipating remote future public needs in many cases. To do that, of course, they have had to borrow very heavily from the Old Country and from the States, and from investors generally. Until 1913 the great bulk of that money was coming from England, and in fact the bulk of it still comes from there; but more and more the proportionate English ratio of investment in Canadian bonds and stocks has been declining in favor of the United States, where the ratio has been increasing; but even now, from the last figures that I have seen compiled, Canada is getting something like seventy per cent. of its borrowed funds from the Old Country, which is being drawn into Canada largely for municipal and government improvements.

The price of money then for public improvements up there is largely a matter of money conditions in the Old Country. No matter what people may say, the price of money, while it is primarily based upon economic conditions, it is also affected by *sentiment, there is no question about that*: Financial men, brokers, underwriters and sellers of securities, have agreed on that, in spite of the fact that some people have advanced the theory that that is not correct. ***Sentiment does govern to a certain extent the price of money*** and the availability of money even for municipal or government use. Sentiment affects the price of money in England. In the case of the City of Toronto, the Mayor and the City Comptroller first offer their loans to big banks and underwriters in London, or elsewhere in England, and if they do not get satisfactory offers, as was the case with the small loan of $1,200,000 in 1913, they may offer the loan elsewhere, which they did in 1913. On that particular occasion it was taken by N. W. Harris & Co., of Boston, and others in the United States; but the usual procedure there is to offer it to the Old Country first. Of course the action upon any offering there will be influenced by the sentiment that I have referred to. It may be asked, what has sentiment to do with that? It must be remembered that the thought will occur to the money-lenders there that the bonds offered are for a specific purpose, and they will ask first, "Where is that money going?" Suppose the answer

is, "It is going into a plant for the benefit of the City of Toronto," the next question is, "Who is going to get that money?" "Why, chiefly the people who furnish the equipment, in New York, Pennsylvania, Illinois, or anywhere in the United States, who make the machinery." Then the Londoner's remark is, "Well, so much of the machinery comes from the United States, and the money comes from England, or at least seventy-five per cent. of it." Now this may be part of the answer to this question.

Another reason that I see for opposition to this steam reserve plant is again sentiment—local sentiment. They do not wish to acknowledge that the hydro-electric system, which is a purely waterpower scheme, is a failure. They do not want to acknowledge that there is any necessity for a steam reserve plant. They want to try to prove this; but as yet it has not been proved satisfactorily that they can depend alone upon hydro energy for a constant and dependable service all the year around: But to put this steam reserve plant in will be practically *admitting* (as is contended by some of the newspapers—and the newspapers have a great deal to do with moulding public opinion)—*the failure of the hydro-electric as a dependable independent system*. Some of the newspapers have been very conservative in their statements, and others have been quite the contrary. Those that have defended the hydro-electric may yet have to back down on that proposition, and will have to admit that they were in the wrong, because their own Commissioners of the hydro-electric have acknowledged that they want this reserve plant and that it is necessary. So that it presents a rather complicated condition. The private competitive hydro-electric company has spent about three-quarters of a million in increasing the size and bringing up to date their own steam reserve plant.

Because of this comparison of Mr. Bolton's his paper is very interesting to me, and if it were not against ethics or precedent, I would like very much to be able to give it to both sides of the press in Toronto and see what they will do with it. I suppose it would not be ethical, and therefore not proper.

President Lewis: I think that this paper is particularly interesting to us in its effect upon the aspect of the electric heating, which is certainly coming into its own in the near future, within our time, and particularly with reference, I believe, to the improved insulation of buildings.

Mr. Davis: I would call the attention of this Society to the fact that it is evident that the companies who build water-power

plants are practically announcing that they can heat the plants cheaper by steam than to use the electric current they are developing for that purpose. This is evidenced by the fact that they are putting in steam heating plants in all the large electrical power houses even where they are generating 25 to 100,000 H. P. At the large power plant in Sault Ste. Marie steam is used; also at the large development plant on the Mississippi River at Keokuk, Iowa. When we consider that such immense plants put in steam heating in place of using electrical current for heating, it is quite evident that it is very much cheaper to heat by steam than by electrical current.

Prof. John R. Allen: There has been a general impression that water power was more certain in its operation than a steam power plant. Recently I have been connected with the management of a water power company in the West where we have four plants upon which they depend for power. We felt reasonably safe with the four plants, but we are now building the fifth in order to avoid any difficulty. We may be eventually compelled to build a steam reserve in order to maintain a service constantly. Water power is not continuous. Steam power is more certain. There is always opportunity for a breakdown at a water power plant, according to the experience that I have had in the West.

President Lewis: That would seem to indicate that what is necessary is an improvement in the design of water plants. We have developed our steam engineering to such perfection that water cannot compete with it. We had better turn our attention to the development of water plants as sources of heat supplies.

Prof. John R. Allen: The trouble is that you cannot control the situation if you have a blockade of ice, and other things that are absolutely beyond your control, and which are almost inevitable in the winter season with the water power plant and endanger a shut-down almost any time by an act of the Lord.

Mr. H. M. Hart: In behalf of the Lord I would like to rise and defend His side of it. I think that breakdowns will perhaps happen and that steam may be more dependable; but that does not relieve us from proper engineering effort to utilize to the fullest extent what He has given us.

Mr. Bushnell: Right in line with what our President has said, I wish to suggest that both water and steam power have a broad field of usefulness. I am one of those who are of the opinion that the water power resources of this country constitute

an enormous source of power which we have thus far only partially realized. While there are many obstacles in the way of their development, yet, as suggested by the last speaker, these may be problems which can be slowly worked out in the future. It seems to me that anything which can assist us in postponing the day when our coal measures will be exhausted is of great importance as a means of conserving our natural resources. In all probability the time will never come when there will be another carboniferous era, a time when coal may be deposited in such vast amounts as in the past; and it is our duty as patriotic citizens to look forward to the future when the people of this country will not be provided as we are to-day. In taking this view, we should consider not only the fact that it is necessary to meet the requirements of the present population, but that in a comparatively short space of time, fifty to one hundred years, there will be a vastly greater population; in other words, the demand for coal will be cumulative. At the same time the supply will grow less. Perhaps, no one will question that the price of any commodity is governed by the law of supply and demand. Suppose that we were to wipe out all of the water power plants in existence to-day and should call for the millions of tons of coal that would be required to make up in steam power for the loss of all this hydraulic energy; can anyone doubt but that there would be a marked increase in the cost of coal at the present time? In my own city, Chicago, it has been frequently observed that the coal purchases from the great central steam stations have a very marked effect on the market for all coal used in the city. My experience in operating steam heating plants in Chicago is that we are paying for coal about forty per cent. more per ton than we were ten years ago. One fact which is brought out in Mr. Bolton's paper is that it requires twice as much labor in England and Wales to get out the coal. It is probably a fact that they are going further down into the coal strata, with a consequent increase of difficulty in hoisting the coal. As the years go by and our surface coals become exhausted our cost for coal will necessarily increase—due not only to the greater effort required in hoisting the coal to higher levels, but also to a probable increase in the price of labor. It seems to me that in pointing out the economy of steam plants at the present time we should not lose sight of the fact that to a certain extent this economy is possible through the competition of water power and its use to such a large extent. I believe that while in a great many in-

stances we can figure out a present economy by the use of steam power, nevertheless in the future we will have to depend more and more on water power.

In closing, I call attention to this thought—as the rivers sweep onward to the sea, the power once passed can never be reclaimed. Coal, which is simply another form of stored energy, can lie embedded in the mines for a thousand years, and at the end of that time be just as available as it is to-day. Is it not then a wise policy, and one in line with the new thought of conserving our natural resources, that we encourage the establishment of hydraulic power stations wherever practicable? While in some cases coal may at the present time have an economic advantage as a producer of energy, will not this advantage be wiped out in the near future by the inevitable law of supply and demand?

President Lewis: I appreciate the remarks of Mr. Bushnell, but I am afraid that that is rather too altruistic a view for our present civilization. We use the thing that we can get the cheapest. That seems to be our tendency.

CCCLVI.

OUR SOCIETY, ITS AIMS AND OPPORTUNITIES.

J. J. BLACKMORE, MEMBER

A Society organized for the advancement of an art and for the improvement of the status of its members to be successful, must work along altruistic lines.

Each of its members must be ready, and willing to contribute, time, thought and substance to the cause. To the end, that its aims may be advanced and its members uplifted by the co-operative effort of each and every individual who joins its ranks.

No person is happier than the one who is employed in doing helpful things for others. No satisfaction is so great as that derived from the knowledge of having performed a beneficent work.

No one need know by whom such work has been done, yet the consciousness that such has been accomplished will be a lasting source of happiness to the one who, being lifted above selfish considerations, does that which helps to uplift a community or a cause.

This Society now passing through its twenty-first year, has been the means of greatly advancing the art of heating and ventilation. The occupants of buildings are more comfortable and the conditions surrounding them are more healthful, as a result of the efforts of this Society, and the co-operative work of its members.

The field for the operations of the Society is a much broader one than is generally assumed by its members. There is a great deal of work yet to be done. The field is covered with problems that need investigation.

Heating and ventilation are kindred terms, but each has a separate field covering a wide range of useful effort. The operations of which should come within the scope of the work of this Society.

HEATING

The production and utilization of heat in the domestic and manufacturing arts are all within our sphere; and our activities should

be extended to cover the investigation and improvement of all appliances that are manufactured or installed for the purpose of the production or the utilization of heat, excepting only those operations that are clearly within the field of the chemical, manufacturing or power developing engineer.

The work covered by the use of electricity in heating operations has received but little attention from the society and efforts should be made to bring members into it who are interested in this important branch of our industry; its use is more widely extended than is generally known.

The utilization of gas for heating purposes has not received the attention it merits from the members of this society. Yet it presents a field for investigation that is very broad and very easy of access, for almost all of the large gas producing corporations maintain laboratories that are open to the investigator.

The industry of car heating and ventilating, though a very large and important one, has received but little recognition in the efforts of the Society.

VENTILATION

The art of ventilation has even a broader field than that of heating as there is scarcely an industry in which human endeavor is engaged that could not employ the art of ventilation in some form to its advantage.

Some scientists who have closely studied the subject say that the span of life allotted to man is one hundred years and is not restricted to three score years and ten as set forth in the biblical account.

The reason for this conclusion is that most animals who live in a natural environment have a duration of life equal to five times the length of the period required to bring such animals to maturity.

Man matures in twenty years, and should live, according to the opinion of such scientists five times the length of this period, or to the age of one hundred years.

Man in seeking shelter from the elements has created artificial conditions that are not as healthful as those provided outside by nature. Industrial life or the development of the arts, has also introduced conditions that have still further interfered and prevented man from attaining his allotted span of life.

Some of our great insurance companies have tabulated the rate of mortality of those engaged in different industrial occupations by showing the percentage of the deaths per annum per thousand

in each industry and these figures show that we are continually introducing occupations that are detrimental to the healthful development of the race, and unfortunately, we have not yet reached the stage in our development where the safeguarding of the health of the worker is considered as fundamental to the gaining of wealth.

The ventilating engineer has done a great deal towards improving the healthful condition of our buildings by providing means for adequately removing the vitiated air from the rooms and replacing it with pure, fresh air from the outside and he has still further demonstrated the advantage of cleaning or washing the fresh air before delivering it into the building. He has also found that the quantity of moisture in the air is a factor that affects man's condition and efficiency. That the regulation of this moisture is beneficial and the term "conditioning" is becoming a familiar word and will soon become as frequently used in the trade as the word "heating" is in its connection with ventilation.

There is still some unexplained difference between the air as delivered into our buildings and the outer air, that makes the latter more healthful. Probably the most frequently suggested remedy for ills by physicians is "keep out of doors all you can." There is a reason for this, and it is within the province of the members of this Society to search for the causes of, or the reasons for this difference. The search will probably enable us to demonstrate that air can be still further conditioned to make the inside air as beneficial as the outer.

Co-operation with the physiologist and chemist and with committees of kindred societies will be necessary to enable us to go forward in this endeavor. We should welcome every opportunity for such co-operation and take full advantage of it when offered.

The Society should be in touch with every university in the country that has for one of its objects a course of training in mechanical engineering. It should know of what such course of training consists and be prepared to co-operate with all such universities or their engineering departments and be interested enough to suggest from time to time, from the experience of its members, any additions to such course of training as will tend to advance the student in the knowledge of the art to which the Society devotes its endeavors. The Society should be fully acquainted with the equipment in the testing laboratories conducted by the National and State governments, as well as those conducted by the engineer-

ing schools and also with those maintained by manufacturing corporations.

The Society through its committees, should be prepared to suggest what appliances need testing and where necessary to prescribe the manner of such tests; and when such tests have been made, they should be particularly careful that a proper report of such test or tests is made, in which the data relating thereto shall be properly tabulated in a convenient form for ready reference.

This is an age of transition and inquiry and this Society should be a huge question mark and always be "in the van" where any inquiry will yield information that will lead to a better understanding in the working of the forces of Nature.

No mother gives up what she knows so generously as does mother nature, but she only gives it to those who search diligently for the hidden treasures she holds in her keeping.

We must therefore be always searching earnestly for information where it may be obtained and give our best efforts in co-operation with any school or laboratory that may be interested in the investigation of the natural laws that govern the forces used in the production and utilization of heat and who are also interested in the testing of appliances and apparatus to determine their value for the purpose for which they have been produced. This is really the purpose for which this Society was organized and it must continue actively and vigorously its efforts towards the attainment of its important undertaking. When the working of nature's laws are well understood, appliances will be made to utilize them to greater advantage than in the past. The best means of ascertaining how closely such appliances do work in accordance with natural laws is to test them in a laboratory, conducted by men who understand and are skilled in the working of the laws governing the operation under observation. Such a test may be, and generally is technical, but it is also practical when the manner of conducting it is clearly set forth and the results given in such a way that a practical mind can clearly understand how the results were obtained.

Tests of installations in buildings can only be made at the place in which the installation is in operation, but so far as possible, laboratory methods should be followed, and such tests should be undertaken by men who have had laboratory training and know how to record and tabulate the results.

HEAT LOSSES

The writer was recently asked the question, "What information has the Society tabulated as to heat losses of railway cars traveling at different speeds?"

The Society should at once undertake the following work and push it to a conclusion as rapidly as circumstances will permit.

The tabulation of all data relating to heat losses through all kinds of building materials, giving the conducting power and the loss at different outside temperatures and at different wind velocities up to ninety miles per hour. These tests should also cover heat losses through all the metals and *covering materials* used in the art.

Some experiments have been made to determine such losses but the data relating to such has not yet been tabulated into a convenient form for general use.

The compilation of data covering all tests made in recent years should be undertaken at once and when data relating to such tests that have been made does not clearly state or show the conditions under which they were conducted and how the results were arrived at, such tests should be considered as doubtful till other tests have been made to verify them. The testing and recording should be continued till complete and unquestioned records of tests covering the entire subject are entered in our transactions.

Studies into the application of this data to the actual heat losses of buildings should then be undertaken and comparison should be made to determine the additional loss from leakage of joints in putting these materials together.

We should also determine the heat losses that are occasioned when such materials absorb dampness from the outside which must be offset by the heat from within the building.

A Committee of the Society should be charged with the work of collecting data relating to losses of heat by railway cars at different rates of speed plus the wind velocities up to the severest gale they have to travel through.

FUEL

While certain designated committees are working out heat loss problems, other committees should be working on problems connected with fuel by investigating the different kinds of coal, wood, peat, oil, natural gas and artificial gas.

The kind of fuel and the place or part of the country from which it is produced, the best way to liberate its heat for the purposes advocated by the members of this Society.

The geological department at Washington has prepared numerous reports on this subject and has tabulated data of tests of the value of the different kinds of fuel. This Society should collect this data and add to it from its own experiments and tests anything of value that may be necessary to complete the work to a point that our records will give to its members a complete analysis of the subject, supplemented by a digest of the results for ready reference.

Other committees should be investigating appliances for the economical utilization of heat. This field is very wide and begins with the furnace in which the fuel is combined with the necessary elements to produce combustion. Then follows the heat absorbing surfaces that are placed on or in connection with the furnace to take up the heat for distribution or utilization. The appliances offered for this purpose are numerous; are they the best that can be devised? Have we investigated, tested and proved them to the extent we should have done?

A careful survey of the field will show that investigation and testing of these appliances from a scientific standpoint has only just begun.

A great deal of good work has been done by the Society in the ventilating branch of the art particularly during the last six years. The data gathered in tests of fans or blowers to determine their efficiency is very creditable to the gentlemen who have given their time and thought to the investigation of these appliances.

The work should be continued till the practice is standardized and the data collected into a convenient form for reference.

Standard practice for velocities in pipes or ducts for conveying air for ventilation should be adopted by the Society as soon as it is sure such standards have been demonstrated as being correct.

Friction tables for different sizes of pipe at these velocities should also be figured out by committees and the results tabulated for convenient reference before being entered into the transactions of the Society.

Methods of tempering, conditioning and regulating the flow of air need standardizing and opportunities for doing so will be frequent and they should be taken advantage of when offered.

The Society in its efforts to improve the art of ventilation should be in touch with the factory inspection departments of every state that has an active department for this work.

From these sources valuable data can be had that will enable the Society to offer suggestions for improving their conditions.

In this connection there is a great opportunity for the members of this Society and the profession to improve the atmosphere of our factories by conditioning the air to the extent that the product of certain factories may be improved by such conditioning or the output increased by keeping the air in the plant always at the condition best suited to its output.

It has frequently been observed that factories cannot turn out work with uniform speed or quality and the state of the weather is given as the cause.

A proper supply of well conditioned air would probably overcome these troubles.

It is impossible to give a complete program of work to be done in a paper of this size, but the foregoing, I hope, will be sufficient to awaken the members of the Society to a full appreciation of the opportunities for advancing the art that are within their grasp.

DISCUSSION

President Lewis: This paper is an administration measure; the present administration has a definite idea of about how it shall accomplish the work, namely, that when a committee is named, that committee as a rule is given some specific thing to do. Mr. Blackmore has very carefully tabulated some of those suggestions. We would be glad of any further suggestions.

I believe that our success for the future lies very largely along the line of having better papers, better data at our meetings; not that we have not had good ones, but the idea is that specific committees be given specific things to do, and that that will prove an efficient way to operate and will lead to our having more members and to our having better attendance at our meetings. That is why this paper with its suggestions is an administration measure.

Norman A. Hill: My interest in the Society dates back to 1905, when I joined as a junior member. My attitude of mind toward it has always been that of the scholar to his instructor. I have looked upon the older members, many of whom are members

of faculties in universities and consulting men who have devoted a great deal of time to research work, etc., as teachers qualified to instruct the rest of us. In other words, I have regarded this Society as a means of self-improvement, and I believe that the education we receive will enable us in time to educate the public and the trade generally.

It seems to me that ever since I joined this Society every year statements have been made to the effect that what we are trying to do indoors is to reproduce as nearly as possible out-of-doors conditions. I do not believe that statement is correct unless one qualifies it by saying that what we are trying to do is to imitate Ideal Outdoor Conditions. Even when physicians recommend people to stay outside of the house, they mean if the climate is what they want it to be; if not, they try to get them to some place where the outside air is uniformly good. They send them out where they can have special conditions of humidity or temperature such as they believe will be good for the invalid; and it seems to me that we are groping a little bit blindly on this thing and that if we could secure exact data of hygienically ideal outside conditions for the purpose of reproducing indoors we would probably get the answer sooner.

They certainly showed us some wonderful experiments with light at Nela Park yesterday, and we arrived at some conclusions which we could not help drawing for ourselves, and which seemed to point to the fact that they are trying so far as illumination is concerned to reproduce conditions of perfect daylight, not conditions of light on cloudy days or anything of that kind, but on sparkling days in June, or September days when the air is clear and the sun is bright. That's what they seem to be doing at Nela Park.

Now in trying to arrive at a system of heating and ventilation, do we want to reproduce outside conditions irrespective of the weather, irrespective of the fact of whether it is damp or muggy outside? Do we want that same condition in our houses? Suppose the dust is removed, etc.; do you still want the humidity and temperature in your house the same as it is outside? It seems to me that we do not. What we are really trying to do, is not to reproduce outside conditions regardless of weather, good or bad, but to create *ideal* conditions, and so far as possible make our interior air independent of exterior conditions of temperature and humidity. Let us try to arrive at a standard of temperature and humidity. Of course there will be varying opinions about

this for anyone who has lived up north may say that a temperature of 65 or 68 degrees to him is too warm: Or again, we have a lot of English people in Canada who insist upon their houses being kept at 60 degrees, which they feel is as warm as they want it. So there is sure to be differences in arriving at some approximate standard of what is a perfect day; but if it can be scientifically reached; just as the light experts seem to have come to the conclusion that perfect light is a perfect imitation, or as nearly as they can approach it, of day light, it seems to me that our standard is to get a consensus of opinion of what is a perfect day, find out what the temperature and humidity conditions of the air are, and try to make our building interiors come as close as possible to that condition by artificial means.

Harry M. Hart: I would like to say in reply to Mr. Hill that a great deal of work along that line has already been done by the members of the Chicago Commission on Ventilation in the experimental work on the Normal School. Quite an interesting paper has been given by Professor Shepherd on the subject of "Comfort Zone"—a combination of temperature and humidity and certain conditions indoors.

Mr. Norman A. Hill: I will ask whether light has been taken into consideration in that, because it seems to me impossible for a heating and ventilating man to keep away from illuminating engineering problems. If that theory is not new or original, I claim no credit for it whatever. If that theory is good that we should try to duplicate a perfect outside day, we cannot get away from illuminating as part of our problem as heating and ventilating engineers, just as they had to inject the colors that were missing in that light yesterday to get the proper results and bring out the painting. We may have to take into consideration lighting as part of our heating scheme, so that a day that would be dull and disagreeable indoors, by artificial lighting in connection with artificial heating and ventilating would present the conditions of a perfect clear day outside.

President Lewis: I might say in connection with that, that there are two Commissions on ventilation, one in New York, one in Chicago. To conduct a scientific investigation of that nature with satisfaction it is necessary that the members be in close contact. It is impossible to bring out very good results with a scattered committee; therefore we have felt rather pleased that we had a large representation in each of those Commissions. They are provided with funds, they meet very often, and they

have in addition a considerable laboratory equipment as well as the advice of experts and scientists in each case; and in that connection I have no doubt that lighting will be considered. If you have no objection, at this time I think it would be wise to hear the tentative report of the Chicago Commission on Ventilation, which Mr. Hart is prepared to read.

Mr. Reginald P. Bolton: Before closing the discussion on Mr. Blackmore's paper I would like to say as one of the old members of the Society that this paper represents a very interesting stage in our operations. It has been said with great justice that the activity of any organization is represented by the energy of the Secretary; and surely we have here strong evidence of the amount of detailed thought which Mr. Blackmore has devoted to our work and our purposes. This paper constitutes an index of the work in which we as a Society are so greatly interested.

One of our difficulties in the past has been that our members have not realized the opportunities before them and the field that we are stepping into. I can recall when the title of this Society was first adopted, "The Society of Heating and Ventilating Engineers," how many men remarked, "What a very restricted field you are laying out for your members! Why, the American Society of Mechanical Engineers already occupies that field. That is merely a branch of mechanical engineering." But see how time has brought about a different view, how our art has broadened out and covered all phases of heat and health engineering. In Mr. Blackmore's paper we find a tabulation of the things that we can undertake to study with profit to ourselves and to our fellow-beings.

If one subject has been omitted from this rather extensive list it would be that to which Mr. Hill has been drawing attention, namely, the dust content of the atmosphere of our country at large and of our cities in particular. This is a subject on which I have been engaged recently. The dust condition in our city atmosphere is something that we should deal with not merely as a deficient condition indoors, but we must go outside and correct the trouble at the source.

Let me draw your attention to the emission of cinder ash from our chimneys. It has been well established that at least 1 per cent. by weight of coal that is burned under forced draft is emitted as cinder or dust from the tops of smoke-stacks. In recent tests which I took part in, in New York City, on a very large scale at an enormous power station, it was found the rate of

emission of cinders and dust out of the stacks, under the rate of combustion of 31 pounds of coal per sq. ft. of grate per hour was nearly 1½ per cent. of all of the fuel that was burned. Now when power stations burning 2,000 tons of coal a day are emitting cinder and ash at the rate of 20 or 30 tons a day into the atmosphere of that part of a city in which they are located, the contribution to the dust problem becomes a very serious proportion. From recent observations taken at the Metropolitan and Woolworth towers in New York City it was found that the dust particles per cu. ft. at the base of those buildings ran in the case of the Woolworth building as high as 240,000 particles per cu. ft. while at the top of the tower it was nearly 27,000 and in the upper air at some distance away only 18,000. That illustrates the conditions that we have to contend with in ventilation near the ground level.

I believe that I was the person that was responsible for the request from the Secretary for information as to heat losses from the operation of railway cars. Finding nothing in our own Society transactions I thought at first that was rather to our discredit, but I found later that there is nothing in the transactions of any other Society—for I searched them all—and consequently here is an opening for a discussion of another subject by our Society. The question arose in connection with the temperature conditions of the air in our subways. Vast numbers of people in New York City are traveling every day in the subway, occupying at least an hour, and often an hour and a half of their time in that atmosphere. This is a matter that I think is worthy of our devoting some time and attention to, if not some expense.

And that brings me to the point that these investigations very often cost money, and one of the limitations that has prevented our going into many of these things is that our committees have to do all their work voluntarily, and are not even allowed expenses, but spend their own money. This has been due to the fact that we are a small organization and not a rich one. But I believe that there are many of our members who are so sincerely interested in this line of work that they would be glad to contribute to a research fund. I feel that we ought to have a research fund established to which some of us can contribute and which can be placed at the disposal to a certain extent of committees on some of our important investigations. If that were done some of the large institutions which have

funds that are available for such purposes, might be so influenced as to divert part of their riches into our coffers, and allow us to investigate matters that affect the health as well as the comfort of the community, just as much as investigations that are now proceeding in many directions from medical and surgical standpoints.

Mr. J. H. Davis: Referring to the question of car heating and to the lack of data regarding the amount of surface, would say that I believe one of the reasons that there has never been any data on that subject is the fact that heating cars by other means than stoves had always been in the hands of a very few companies. It was first taken up by Baker-Smith & Co., New York, who developed the patented system in which salt water was used, and I fortunately received my early education in the steam heating line with that company and was familiar with their method of heating cars and its manner of erection. Their method for many years was to put in 300 feet of 1¼ inch pipe, which seemed ample for the cars that were made in those days. The pressure generated in the heater ranged anywhere from 10 to 150 pounds depending upon the weather, increasing the pressure, however, with the additional heat necessary for the colder weather conditions. In later years when their patent expired, and steam was adopted, the car heating business passed from Baker-Smith & Co. to concerns who made a specialty of car heating and they adopted various types of vapor systems and put in large amounts of heating surface as the size of the cars increased.

At one of the meetings of the Master Car Builders at Atlantic City, I asked some questions regarding how much additional surface they were putting in the large steel coaches as compared with the older types and they advised me that the additional surface approximated about 25 per cent. but I received no actual data as to the amount of surface that was used, although it can be readily obtained, as these companies put up complete equipments in their booths with the same amount of surface, connections, etc., as there would be in actual cars.

Mr. H. R. Linn: About fifteen years ago I had occasion to assist in making some tests to determine the heat losses of passenger trains under varying wind conditions. We made these tests on a twelve car train and found that we had greater heat loss when the train was standing still, with a side wind blowing

off the lake, than when the train was running thirty miles an hour against a head wind.

We ran these tests to determine the maximum amount of steam which we had to take care of through our train line, but as the conditions put upon transcontinental trains is so great we did not carry these tests to any great length.

It seems to me that until the railroads have adopted some standard form of car construction it will be folly to undertake to collect any reliable up-to-date data, although I would be pleased to see such data collected by this Society.

Mr. Blackmore: I want to add a word to the discussion. The initiative of the engineer is a phase of his status to which he has not paid enough attention. When Mr. Hill was speaking about the conditions that we should aim to have in our houses, and whether they should be ideal conditions or conditions as they might be found outside, it occurred to me that that is something which should be left entirely to the initiative and ingenuity of the engineer; the engineer is not restricted simply to reproducing outside conditions if he can create better ones. If the engineer can introduce better conditions inside than exist outdoors he will greatly benefit the race.

CCCLVII.

SOME TESTS ON THE HEAT TRANSMISSION OF DIRECT RADIATORS AT LOW DIFFERENCES IN TEMPERATURE

ALSO

ON THE HEAT TRANSMISSION FROM STEAM TO WATER IN SPECIAL FORM OF CONVERTOR.

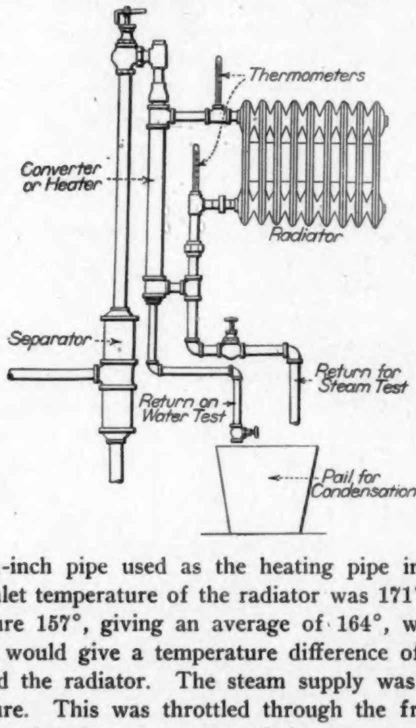
J. A. DONNELLY, MEMBER

Tests of steam radiators for condensation and transmission of heat at ordinary differences in temperature of 140° to 150°, are made with comparative ease. Tests with greater differences in temperature, even up to 300° or 350° difference, are not at all difficult if high pressure steam is available and if the type of radiator chosen is one that will stand the working pressure.

Tests at lower differences in temperature are not easily made with steam unless by the use of some special form of apparatus. Of course, it is possible to use steam at a nominal pressure and test a radiator in a room the temperature of which is extremely high. This, however, while duplicating conditions for drying rooms, does not duplicate conditions found in every day practice where the room is usually 70° and the radiator may be as low as 120° to 170°.

The apparatus as shown in the accompanying cut was constructed in order to see if reliable tests could be made under the conditions suggested, with the thought that at some future time tests similar to these might be conducted on a larger scale. The radiator was of sheet steel, hot water type, 14 inches high, 9 sections, rated and containing practically 12 sq. ft. of surface. The convertor used for heating the water was made with a 1½-inch outside pipe and was fitted with an interior pipe varying from ¼-inch to 1 inch. This pipe extended through a bushing at the bottom, the upper

end terminating inside the 1½ inch pipe a short distance above the upper connection to the radiator. The water between the two pipes circulated to and from the radiator through 1 inch connections. Thermometers were inserted in the flow and return connections, the average temperature of which was taken as the average temperatures of both the radiator and the convertor.



With a ¼-inch pipe used as the heating pipe inside the convertor, the inlet temperature of the radiator was 171° and the outlet temperature 157°, giving an average of 164°, which with the room at 72° would give a temperature difference of 92° between the room and the radiator. The steam supply was at about one pound pressure. This was throttled through the fractional valve on the inlet so that the temperature of the steam was at 212°. A small amount of steam was allowed to flow from the bottom of the convertor so that the pressure and temperature could not rise above this point. Under these conditions, the convertor and radiator condensed 2½ lbs. per hour. This multiplied by 970 B.t.u. per pound gives a total of 2,425 B.t.u. per hour, which if divided by 92 (the temperature difference) gives 26.33 B.t.u. per hour per degree difference in temperature.

The drain valve was then opened and a test was run with the convertor and the entire radiator under steam at atmospheric pres-

sure. Under these conditions the radiator condensed 4 lbs. 6 oz. per hour, thus giving off 4343.75 B.t.u. which divided by the difference in temperature between the room, 74°, and the steam, 212°, which gives a temperature difference of 138°, gives a transmission of 31.48 B.t.u. per hour per degree difference. The difference in transmission between 31.48 and 26.33 is 5.15, which divided by 31.48 would seem to indicate that the radiator gave off 16.3 per cent. less heat per degree difference in temperature, with 92° difference, than with 138° difference. In Carpenter's "Heating and Ventilating of Buildings," page 86, the transmission per square foot per degree difference is given for 140° difference at 2.48 B.t.u. and at 90° difference as 2.24 B.t.u. with 12 inch thin radiator surfaces.

From this, it would seem that the tests upon which this table was based indicate that a radiator with 90° difference in temperature would give off 10 per cent. less heat per square foot per degree difference than with 140° difference.

With ½-inch pipe inside of the convertor in place of the ¼-inch, the average temperature of the radiator was increased only 8°, that of the inlet being 181° and that of the outlet, 163°. This was with a room temperature of 72°, giving a difference of 100°.

With a ¾-inch pipe in the convertor the inlet temperature was 186° and the outlet temperature, 166°, giving an average of 176°, which with a room temperature of 75°, gave a temperature difference of 101°. With a 1-inch pipe in the convertor, the inlet temperature was 188° and the outlet temperature, 160°, giving an average of 174°, which with a room temperature of 75°, gave 99° difference in temperature. From these figures it would seem as if little if any advantage was gained by increasing the surface of the heating pipe. Evidently the cutting down of the area through which the water flowed between the two pipes increased the friction so that but very little benefit was gained by the increased surface.

The convertor was nominally 2 feet 8 inches long, which gave the length of the ¼-inch inner pipe as 2 feet 6 inches, or .357 square foot. This divided into the total, 2,425 B.t.u. gave a transmission of 6,792 B.t.u. per square foot which with a steam temperature at one side of 212° and an average temperature of the water on the other side of 164°, or 48° difference, gives a transmission from steam to water under these conditions of 141.5 B.t.u. per square foot per degree difference.

DISCUSSION

Prof. John R. Allen: I should like to ask Mr. Donnelly if any provision was made for taking account of the radiation of the convertor or pipe connections; or were those connections covered?

Willis H. Carrier: I understand from those that have made radiator tests that there is a great difficulty in getting standard conditions for testing or even in getting two successive tests to show corresponding results. Different types of radiators seem to vary much with respect to the nature of their surfaces and in regard to the effect which these surfaces have upon the convection factor. Another element which causes a great variation in apparent results obtained in heater tests, is the difficulty in measuring the condensate accurately owing either to entrainment of moisture in the steam supply or to evaporation from the condensate itself.

The rate of heat transmission quoted by the author is considerably higher than that customarily given for standard conditions of radiation. I think that possibly 1.7 B.t.u. per square foot per hour per degree difference in temperature would be about the average of the standard practice. Of course if one were to take a single pipe radiator with perfect air circulation, etc., I suppose that the heat transmission might go up as high as 2.5 B.t.u. per square foot per degree difference in temperature as quoted by Mr. Donnelly.

Prof. John R. Allen: We have been carrying on radiation tests for about twenty years at the University. We have quite an accumulation of tests. Mr. Carrier is right in his statement in regard to heat transmission. We find that the heat transmission varies from 1.6 to 1.7, the average being about 1.67.

There are many conditions that enter into that. One of the conditions that is often lost sight of is the fact that the announcement of heat radiated from the radiator depends upon the room itself. We formerly made our radiator tests in a room without an outside window. We changed to a room that had a large amount of window surface. The heat transmission through the radiator increased about ten per cent. The radiator loses heat in two ways, by convection and by radiation, and the radiation loss depends upon the temperature of the surrounding surfaces. If you have window surfaces surrounding the radiator the tem-

perature of which is low, the radiation from the radiator is necessarily high and the heat loss from the radiator is increased.

In order to compare radiators there must be a standard room in which to compare them. You must be certain that dry steam is used in making the tests. In order to do that high pressure steam is brought through a reducing pressure valve, so that we are sure to have superheat; the heat of the superheat is allowed for in making the tests, which is only a matter of one or two degrees, a small correction.

It makes a difference whether the radiators are of the one, two or three column type; the spacing is also an important factor, as it effects the ease which the air can pass along the surface. If you take an ordinary two-column radiator and increase the spacing one-half inch, you will increase the heat transmission about ten per cent. through the radiator. In comparing radiators the air area between the surfaces should be known in order to give an exact comparison.

The amount of heat transmission is slightly affected by the moisture conditions of the air in the room. As the moisture in the room increases the heat transmission diminishes. Under extreme conditions the heat transmission will vary about five per cent. depending upon the moisture condition in the room.

There have never been laid down any standard conditions for testing. This is one of the things that this Society might properly take up, the establishing of rules for standard testing of direct radiation. Of course each one of these factors in itself is small, but accumulated they may show marked variations that would easily account for the differences we get in the various tests that are presented to different societies.

A standard room for such a purpose should be a room containing about the usual amount of window surface. If you test a radiator in a room with the standard amount of window surface, and then test the same radiator in a greenhouse, you will get a very marked difference running as high as twenty per cent. in the amount of heat transmission; so that there are many factors that should be considered in these tests other than the mere radiator itself.

Mr. H. M. Hart: While the remarks just made by Professor Allen and Mr. Carrier are very interesting, yet I do not believe that they can be construed as referring to this particular paper, because as I understand this paper, it is merely to show the difference in heat transmission at different degrees of tempera-

ture between the radiator and the room. Now as a comparison I think that the discussion that has taken place is not germane to the subject.

President Lewis: I grant that what you say is true; still, I feel that it is very hard to limit discussion absolutely to the matter in hand and to say that we shall not catch these jewels that fall from the lips of our distinguished guests and through which these discussions become valuable to our members. Mr. Donnelly, will you answer the gentlemen?

Mr. J. A. Donnelly: I would like to ask Professor Allen what he thinks of this suggested method of testing a radiator at low differences of temperature, and whether they have made any tests of radiators. This was intended to bring out the factor of hot water heating, or rather to search out some aspect from which it seemed to be available. I would like to have the opinion of some of the members here.

I quite agree with Mr. Hart that they have not touched the subject that I wrote about which goes to show the importance of a proper perspective, as the President says, and also the importance of a proper title for the paper. This was not to show how much a radiator would do, but comparatively how much it would do. I would like to have Professor Allen or some others tell us what they think about this method of testing a hot water radiator by using steam. I would like to see if I could get some facts in regard to that before I close the discussion on it.

Secretary Blackmore: Mr. Hart went at the core of the matter when he stated the purpose of the paper. I had some conversation with Mr. Donnelly regarding it, and Mr. Donnelly said his idea was to verify work that had been done. Mr. Donnelly finds from the reference to Carpenter that there is approximately 10 per cent. less heat per square foot per degree of difference given off with 90 degrees difference of temperature than with 140 degrees difference. Mr. Donnelly in his tests under practically the same conditions found 16 per cent. We know nothing about how Mr. Carpenter's tests were made, but the fact remains that there is a difference of 6 per cent. between the results that Mr. Carpenter apparently got and the results that Mr. Donnelly gets in his tests.

Mr. J. A. Donnelly: I would say in closing as Mr. Blackmore indicates, the heat given off by the convertor and by the pipe both under hot water and steam was really due to their tem-

perature, and piping was not considered. The total surface of the radiator was about 12 sq. ft. You might consider the surface of the pipe as about 2 sq. ft. additional, so that there was approximately 14 sq. ft. of surface in the interior and the pipe. 2.5 B.t.u. per square foot compares very favorably with 2.48 and 2.24 as given by Professor Carpenter, so that one test rather verifies the other. With radiators 38 inches high or more it drops down to 1.6 and 1.8 as mentioned by Mr. Carrier.

One other point brought out by Mr. Carrier is that the degree of temperature difference between the radiator and the air is not the difference between the radiator and the room but the difference between the radiator and the air immediately around it. That can be checked by putting a thermometer below the radiator. I have made some such tests and found that though the difference of temperature between the radiator and the room remained constant, the difference between the radiator and the air below the radiator might vary. That condition occurs when there are different weather conditions and varying amounts of leakage through the windows, or when the temperature is affected by the adjoining rooms; and even though you get your own room right, if it is in a building where there are other rooms somebody else may get uncomfortable and doesn't think it will do any harm if they open a window in the adjoining room, which will increase your radiation while your room temperature may remain practically stationary.

CCCLVIII.

REPORT OF A SPECIAL COMMITTEE ON BLOWER SYSTEMS FOR HEATING AND VENTILATING.*

A. M. FELDMAN, CHAIRMAN

BLOWER SYSTEMS, WHICH ARE OFTEN AN ECONOMIC NECESSITY, USUALLY INTRODUCE AN ADDITIONAL HAZARD CONTRIBUTING TO THE CAUSE AND SPREAD OF FIRE, PARTICULARLY WHEN USED FOR CONVEYING STOCK AND REFUSE. IT IS IMPOSSIBLE TO ELIMINATE THE FIRE HAZARD FROM SUCH SYSTEMS, BUT REASONABLE SAFEGUARDS CAN BE PROVIDED TO REDUCE IT.

The general standards applicable to blower systems are to be subdivided into two classes:—

A. Heating and Ventilating Systems.

B. Stock and Refuse Conveying Systems.

Class A

HEATING AND VENTILATING SYSTEMS

1. Blowers. (The word blowers is used to include blowers and fans.)

a. Blowers to be so located as to be accessible for repairing and lubricating.

b. Casings to be strongly built and properly reinforced where necessary; joints to be air tight.

Casings and runners should be entirely non-combustible, and large enough not to require overspeeding.

To prevent accidents, openings into casings shall be protected with substantial screens or their equivalent.

c. Bearings and journals to be constructed in accordance with

*Report also read at the meeting of National Fire Protection Association.

the best modern machine design and so proportioned as to prevent overheating. The bearings shall be self-oiling and so designed as to prevent leakage of oil. They shall be located outside of casings or ducts wherever possible. If located inside of casings or ducts oilless self-lubricating bearings shall be used, made of bronze bushings fitted with plugs, such as graphite or metaline.

2. Ducts. (The word ducts is used to include ducts, flues, pipes and tubes.)

a. Openings through floors for the circulation of air from one story to another shall not be used.

b. The passing of ducts through fire walls should be avoided wherever possible. Where ducts pass through fire walls they should be provided with automatic dampers located on each side of the wall through which they pass. (See Fig. 1.)

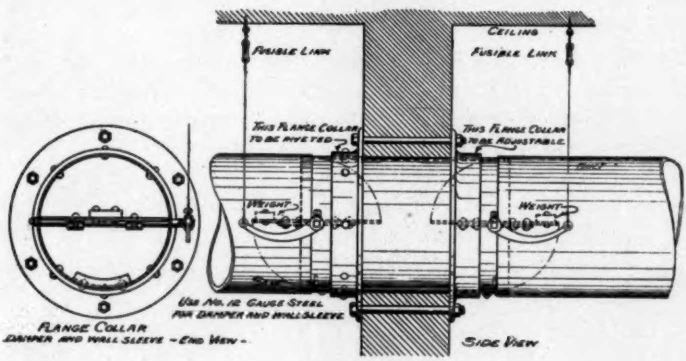


Fig. 1

c. All ducts passing through floors shall be made of or protected throughout by approved fire-resisting material, not less than 4 inches thick.

d. Where ducts serve more than one floor, automatic dampers shall be provided on all outlet openings directly from such ducts and at all connections with branch ducts. (See Figs. 2 and 3.)

e. Entire system of ducts to be self-contained; no rooms, hallways, attics, hollow spaces, voids, nor other portions of the building to be used for air chambers or ducts, unless of fire-resisting construction, and then only by permission of the Inspection Department having jurisdiction.

f. Ducts to be made of galvanized iron or other approved non-combustible material. The same applies to enclosures of steam coils used for heating air.

g. To be thoroughly braced.

h. To be substantially supported by metal hangers or brackets.

i. Where subject to mechanical injury, ducts to be properly protected.

j. In no case shall the clearance between any metal ducts and combustible material be less than 1 inch.

k. Joints between ducts and floors, walls or partitions to be made tight by non-combustible material.

l. Outlets on supply and exhaust ducts should always be protected by means of register faces or wire screens.

m. Intake of air to be from outside except in re-circulating systems, and should be taken only from areas containing non-combustible material. Intakes to be protected with rolling shutters or heavy doors.

Intake and intake rooms, steam coils, blowers, etc., also ducts connecting blowers with vertical ducts which pierce floors, shall be segregated in a room cut off by fire-resisting partitions from other portions of the building. Where any such ducts must of necessity pass through other portions of the building, they shall be protected by four inches of approved fire-resisting material as required for ducts passing through floors.

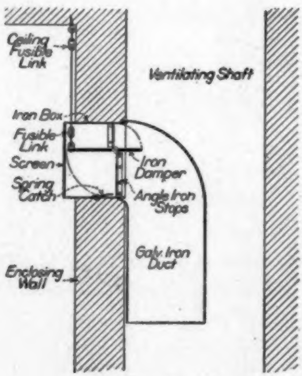


Fig. 2

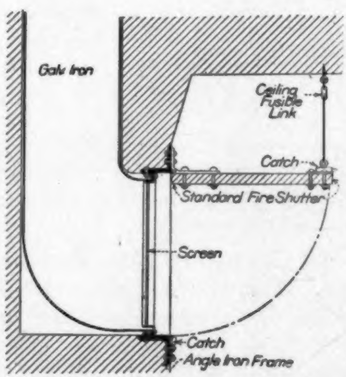


Fig. 3

Figures 2 and 3 illustrate methods of installation of fusible link dampers.

3. VENTILATION OF COOKING APPLIANCES

a. Ventilating ducts used to carry off the grease laden vapors from hoods over cooking appliances, especially in kitchens of large restaurants and hotels, shall be constructed similarly to boiler smoke flues and if of metal to be of not less than No. 16 U. S. gauge, so substantially built that the grease and gum could be removed from the interior by burning out under a flash fire.

b. The ventilating ducts should be an independent system in no manner connected with other house ventilating systems.

c. Ducts should not be connected to stacks, chimneys, or flues, used for other purposes.

d. A live steam jet should be provided at the end of the duct nearest the cooking appliances.

CLASS B. STOCK AND REFUSE CONVEYING SYSTEMS

THE HIGH VELOCITY OF THE AIR AND THE INFLAMMABILITY OF THE STOCK OR REFUSE WHICH THESE SYSTEMS ARE USUALLY DESIGNED TO HANDLE MAKE THEM ESPECIALLY HAZARDOUS.

THE SPECIFIC REQUIREMENTS OF A VENTILATING SYSTEM DETAILED UNDER CLASS "A" SHOULD BE APPLIED TO THE STOCK AND REFUSE CONVEYING SYSTEMS, ALSO THE FOLLOWING:—

4. BLOWERS

a. Blowers shall be installed on proper foundations and secured in place in a manner subject to the approval of the Inspection Department having jurisdiction.

b. Bearings of blowers shall not extend inside of blower casings or ducts.

c. It is recommended that oilless self-lubricating bearings be used, made of bronze bushings with plugs such as graphite or metaline.

d. Connections between discharge end of blower and main duct to be made so as to prevent leakage of fine dust.

e. Blowers through which inflammable materials pass shall have blades of composition, copper or brass. Ample clearance to be provided for all blades.

f. Blower systems should preferably have an emergency or automatic control to shut them down in case of fire. This may be done automatically by means of devices utilizing fusible links, thermostats, or automatic sprinklers. Such installations to be subject to the approval of the Inspection Department having jurisdiction.

5 DUCTS

a. Ducts for conveying stock and refuse should be made of suitable non-combustible materials, preferably galvanized iron with all joints riveted and soldered.

b. Lock joints are acceptable for longitudinal seams in pipes used under suction and in small pipes.

c. Spiral pipes to be full riveted and soldered.

d. All joints shall be made dust-proof.

e. The minimum thickness of metal used shall be as follows: up to 12-inch diameter to be No. 24 U. S. gauge; 12-inch diameter and over, No. 22; 24-inch diameter and over No. 20 gauge; 40-inch diameter and over, No. 18 gauge.

f. Provision should be made for the wear due to friction, at all points of change of direction, by making long bends, by using heavier metal and in cases where abrasive materials are to be conveyed, by inserting an approved form of inside lining that may readily be renewed.

g. Suitable tight-fitting sliding clean-out doors to be provided on all conveyor ducts at sufficient intervals to facilitate cleaning of ducts or removing obstructions.

h. Suction ducts should be provided at all machines producing dust or combustible refuse and connected to exhaust fans.

i. "Sweep-up" pipes should be so protected as not to admit material which would be large enough to damage blower.

j. When possible a trunk line should be run on the outside wall of the building with ducts from each machine and each floor, passing out directly through the wall and discharge into the trunk line. If inside of building, the trunk duct should be overhead rather than under the benches.

k. The air vents from the system shall discharge outside of building.

l. Where dust or readily inflammable material can accumulate on or near blowers and ducts, they should be grounded to prevent ignition of these materials from a discharge of static electricity such as may be generated by belt.

6. AUTOMATIC SPRINKLERS

There shall be a sprinkler near the feed end, and at the discharge outlet, inside the condenser, if such is used, and also a sprinkler to protect the blower. In some cases, sprinklers may be installed inside the ducts. Such sprinklers should be arranged in an offset or domeshaped casing and not in the direct path of the draft. Sprinklers with smooth deflectors that will not catch the flying stock are desirable.

7. CYCLONE COLLECTORS OR SEPARATORS

a. The cyclones or separators shall be outside the building and so located as not to constitute a hazard to adjacent structures. Their construction and supports shall be of incombustible material. If the cyclone of necessity is placed within ten feet of wooden walls, inflammable structures, or openings into buildings, it should be provided with a metal pipe extending to a point above the main roof, or other safe location.

b. The refuse from the cyclones and separators is to discharge by gravity into a vault as described in Section 9.

c. If the discharge from the cyclone or separator conveys the refuse directly to the fire boxes of boilers, the feed spout should have a break near the furnace, so that when the furnace gets choked the refuse will fall out on the boiler room floor giving the fireman a warning; also it would prevent "back fire" when the fan blowing the refuse is stopped.

d. The aid vent from the separator must never be connected to a chimney.

e. If the air vent carries objectionable dust, as in the case of refuse, such as from grain elevators, etc., the use of a simple air washer, or other suitable device, is recommended for eliminating the dust. A screen should be used to prevent sparks from entering through the air vent.

8. SPECIAL CASES

a. Readily ignitible stock, such as cotton, should not pass through the fan. The system should never be connected directly to picker or other hazardous machines. Systems handling such stock should operate entirely under suction with a device such

as a "condenser," or large separating chamber to discharge the stock from the pipe or conduit before it reaches the fan. Stock should be fed to system preferably by hand. Stock should enter such a system in an upward direction and the pipe should continue upward for at least 10 feet to allow any heavy substances or foreign material in the stock to drop out. If the pipe must leave the room at a lower level a long radius inverted U may be used to obtain the necessary vertical distance.

b. Systems using mixtures of cotton and wool which cannot be handled by condensers and which operate under fan pressure, should discharge to non-combustible bins or boxes with outside vents through screens.

c. Conditions which approach those favorable for explosive mixtures should be subject to a special investigation.

d. The dust from sand-papering machines, granulators and pulverizers, buffing or polishing wheels, emery wheels and from other machines producing a very fine dust, should have a suction system independent of the cyclone, which connects with the refuse vault.

The dust should be settled by spraying in an enclosed chamber of incombustible material, thus eliminating the hazard of the dust room.

Dust from the machines may also be discharged directly into running water if suitable provision is made for its collection and removal.

e. For mills, such as malt, cereals, sugar, celluloid, etc., it is recommended that an explosion flap be provided in a metal pipe leading outside of the building so that in case of an explosion in the mill the flap opens and the explosion spends itself outside the building.

9. VAULTS

a. Vaults for shavings, refuse, etc., shall be located outside and not exposing adjacent property. Walls, floor and roof shall be of brick or other approved fire-resisting material; walls not less than 12 inches thick.

b. Openings, if any, between vault and boiler room should not exceed 9 square feet, and bottom of opening be not less than 4 inches above the level of boiler room floor. Openings to be located at least 8 feet from the firing door of boiler, preferably at right angles and protected by a standard automatic fire door.

c. Vaults to be protected by automatic sprinklers. Where an ample steam supply is available a steam jet may be found as a useful means of protection. The steam jet is to consist of a pipe connection direct from boilers or main steam line and provided with a controlling valve located at a safe distance from vault. The steam jet to be arranged with two branch pipes extending into the vault, the lower pipe to be placed not less than three feet from the floor, and the upper branch pipe to be placed near the ceiling. There should be an equivalent of 1 inch pipe for each 1,000 cubic feet in the vault with number of outlets as follows:—

1	outlet	on	¾-inch	pipe
2	outlets	on	1 -inch	pipe
3	outlets	on	1¼-inch	pipe
5	outlets	on	1½ inch	pipe
10	outlets	on	2 -inch	pipe

d. Where dust-producing machines are used only on a small scale, the dust or refuse may, by special permission of the Inspection Department having jurisdiction, discharge into a substantial metal dust box, or other approved receptacle located outside the building, in lieu of a vault. The receptacle to have a hinged door or cover, which will readily open and prevent a fire or explosion within.

e. A water tank may be used in lieu of the dust box. In such cases the tank should be provided with water supply, overflow and drain pipes. On the water supply pipe a proper float controlled valve shall be installed to maintain a constant water level. It is recommended that the end of duct be submerged into the water at least one inch.

DISCUSSION

Secretary Blackmore: This report shows us the great value of co-operation with other societies. It is quite possible that if some of the members of our Society had not been on this Committee that some conditions would have been inserted by the Committee of the National Fire Protection Association that would have been too onerous for the heating contractor or for the consulting engineer. Hence in working together the Heating Engineers can in a measure keep other societies from framing ordinances that might be objectionable or unnecessary in the construction of heating plants.

Mr. J. A. Donnelly: Some seven or eight years ago an insurance broker in New York asked me to join this organization, the National Fire Protection Association. After I joined I called the attention of the Heating and Ventilating Engineers to the fact that they were eligible as a Society for full membership. The National Fire Protection Association is formed of Insurance Boards, Boards of Fire Underwriters and other organizations interested in fire protection.

The serious side of this situation is that we can accomplish what we want very much more easily through the National Fire Protection Association than through this organization.

In some sections of the country we found that air for ventilating in school rooms had been taken from vitiated air of class rooms through cloak rooms, a very objectionable practise. In order to stop it we had to go to the State Legislature and get laws passed. We have put some clauses in this report forbidding the use of such spaces as cloak rooms as ventilating spaces as not being good engineering practise.

If this is adopted and enforced through the members of the Fire Protection Association it will insure its being done.

A Member: I would like to ask if Mr. Donnelly can tell us why this paragraph *l* was put in: "Outlets on supply and exhaust ducts should always be protected by means of register faces or wire screens?" Can any one tell me from a fire standpoint why you need a register or wire screen on an outlet, what good is it going to do from a fire standpoint?

Mr. J. A. Donnelly: As these things are discussed more and more you will find that more and more refinements will be put in the requirements. No doubt the size of mesh should be specified in the same way as a safety guard is specified. Unless these things are specified the insurance men will give you their interpretation which you will not possibly get along with as easily as you would with the law, or otherwise they will force a high insurance rate.

CCCLIX.

PART OF REPORT OF EDUCATIONAL COMMITTEE OF THIS SOCIETY AND THE NATIONAL DISTRICT HEATING ASSOCIATION.

TEST OF LOW PRESSURE STEAM VEGETABLE COOKER

Your committee appreciates the desirability of popularizing the use of low pressure steam consuming devices that operate satisfactorily on a pressure not exceeding two pounds and will return all condensate without waste to the meter. We find many devices used in Cooking, Laundry and Process work, using steam at pressures varying from 2 to 60 pounds per square inch which could have been designed to give in many cases an equal service at a pressure not greater than 2 to 3 pounds. Other fixtures are designed to utilize steam at graduated pressures in open receptacles with extravagant use of heat units and a total waste of the condensation. The following test describes a vegetable steam cooker which satisfactorily replaces this undesirable class referred to above. This test was conducted by the Standardizing and Testing Department of the Edison Electric Illuminating Company, of Boston, February 10th and 11th, 1913.

This cooker was installed in a popular down-town restaurant and the test was conducted under actual conditions, the observers in no way interfering with regular routine operation of the device.

Average number of persons served per day, 2,000.

Average steam pressure on vegetable cooker during test, 1 to 1.5 pounds per square inch.

A report is given below of tests made February 10th and 11th, on a restaurant vegetable steam cooker, manufactured by the Morandi-Proctor Co.

This cooking fixture is the largest one installed in the restaurant, the dimensions being 5½ ft. by 2 1-6 ft. by 2 ft. It has

four distinctly separate cooking compartments, the dimension of each one being 24 in. by 22 in. by 8 in.

Steam enters into each compartment by means of a ⅜-inch pipe, and is drained by means of a 1-inch pipe. The steam pressure is regulated automatically so that it cannot exceed three pounds.

Four tables are given at the end of this report showing in detail the results of the test on this cooker.

Tables Nos. 1 and 2 show the time consumed in cooking the various kinds of food, and the amount of gain or loss in weight of the food, during the cooking. Table No. 1 shows this data for February 10th, and Table No. 2 shows it for February 11th.

Tables Nos. 3 and 4 show the number of hours the cooker was in service on February 10th and 11th, the amount of various kinds of food in the cooker during the day, and the total amount of steam required for the operation of the cooker per day.

The steam was measured by means of buckets placed under the drain pipe to catch the condensation. The condensation was weighed whenever food was placed in or taken out of the cooker.

CONCLUSIONS

The following summary of the results obtained from the test are given below:

Date	Total Weight of Food Entered	Total Weight of Food Taken Out	Loss in Weight	Gain in Weight
Feb. 10..	327 lbs. 1½ oz.	329 lbs. 8¼ oz.		2 lbs. 6¾ oz.
Feb. 11..	279 lbs. 5¾ oz.	279 lbs. 1¼ oz.	4½ oz.	

Length of Day Operation of Cooker:

Feb. 10........................5 hrs. 28 min.

Feb. 11........................4 hrs. 44 min.

Amount of Steam used during Day:

Feb. 10......................78 lbs. 10½ oz.

(Plus 4½ oz. which is water gained from food cooked.)

Amount of Steam used per Cooker Hour:

Feb. 11..............................20.9 lbs.

Amount of Steam used per Pound of Food Cooked;

Feb. 11..............................0.35 lb.

It will be observed that some of the vegetables give off moisture, while others absorb moisture. In this restaurant one nearly balances the other during a day's run, as the total weights of the food before and after cooking show a very small difference.

FEBRUARY 10, 1913

Compartment.	Material cooked.	Time in.	Time out.	Weight in.	Weight out.	Gain.	Loss.
3	Potatoes	9:25 am	10:07 am	35 lb 6¾ oz	34 lb 6 oz	16¾ oz	
2	Potatoes	9:25 am	10:05 am	35 lb 15 oz	34 lb 13½ oz	17¼ oz	
1	Potatoes	9:25 am	9:49 am	15 lb 5 oz	16 lb 7 oz		2 oz
1	Green peas	9:52 am	10:07 am	18 lb 9¼ oz	19 lb 4¼ oz		11 oz
2	Sweet potatoes	10:07 am	10:47 am	8 lb 3½ oz	9 lb 6¼ oz		18¾ oz
1	String beans & milk	10:13 am	10:27 am	30 lb ¾ oz	29 lb 8½ oz	8¼ oz	
1	Turkey & roast beef	10:38 am	11:04 am	24 lb 4¼ oz	26 lb 4½ oz		33¼ oz
1	Eggs	11:17 am	11:32 am	4 lb 0 oz	4 lb 0 oz		
3	Potatoes	11:32 am	12:30 pm	37 lb 3½ oz	36 lb 14 oz	5½ oz	
2	Potatoes	11:39 am	12:09 pm	13 lb 12½ oz	14 lb 0 oz		3½ oz
3	Beef	12:46 pm	12:55 pm	6 lb 4½ oz	6 lb 9 oz		1¾ oz
3	Potatoes	1:02 pm	1:14 pm	14 lb ½ oz	14 lb 6½ oz		6 oz
3	Potatoes	3:46 pm	4:26 pm	27 lb 14 oz	28 lb 1½ oz		3½ oz
2	Potatoes	3:48 pm	4:25 pm	12 lb 1 oz	12 lb 3½ oz		2½ oz
1	Potatoes	4:15 pm	4:28 pm	13 lb 6 oz	13 lb 7½ oz		1½ oz
3	Milk	4:45 pm	4:52 pm	12 lb 11 oz	13 lb 11 oz		1 oz
1	Potatoes	5:43 pm	6:01 pm	13 lb 1¼ oz	13 lb 3 oz		1¾ oz
1	Eggs	6:01 pm	6:18 pm	4 lb 0 oz	4 lb 0 oz		

FEBRUARY 11, 1913

Compartment.	Material cooked.	Time in.	Time out.	Weight in.	Weight out.	Gain.	Loss.
3	Potatoes	9:28 am	10:20 am	35 lb 7¾ oz	34 lb 12½ oz	11¼ oz	
2	Potatoes	9:28 am	10:20 am	36 lb 5¾ oz	35 lb 9 oz	12¾ oz	
1	Potatoes	9:28 am	9:56 am	15 lb 14½ oz	15 lb 7¾ oz	6¾ oz	
4	Potatoes	9:28 am	9:66 am	13 lb 12 oz	13 lb 7¾ oz	4¼ oz	
1	St. beans, spinach, peas	9:57 am	10:09 am	27 lb 11½ oz	27 lb 12 oz		½ oz
1	Milk	10:10 am	10:31 am	18 lb 0 oz	18 lb ½ oz		½ oz
1	St b'ns, tomat's, peas	10:10 am	10:31 am	12 lb 14 oz	13 lb 1 oz		3 oz
2	Sweet potatoes	10:31 am	10:64 am	8 lb 3¾ oz	8 lb 5¾ oz		2 oz
3	Potatoes	10:33 am	11:01 am	22 lb ¼ oz	22 lb 1½ oz		1¼ oz
1	Turkey	10:36 am	11:01 am	9 lb 6 oz	10 lb 2¼ oz		12¼ oz
3	Potatoes	11:37 am	12:43 pm	35 lb 8¼ oz	35 lb 4 oz	4½ oz	
3	Potatoes	3:40 pm	4:17 pm	9 lb 8¾ oz	9 lb 10 oz		1¾ oz
2	Chicken	3:53 pm	4:38 pm	9 lb 7¾ oz	9 lb 14½ oz		6¾ oz
2	Potatoes	5:02 pm	5:36 pm	11 lb 5½ oz	11 lb 8¼ oz		2¼ oz
3	Eggs	5:08 pm	5:36 pm	6 lb 13 oz	6 lb 14½ oz		1¼ oz
2	Potatoes	5:36 pm	5:45 pm	6 lb 15 oz	7 lb 2¼ oz		3¼ oz
	Totals		4 hrs. 44 min.	279 lb 5¾ oz	279 lb 1¼ oz	39¼ oz	34¾ oz

FEBRUARY 10, 1913

Food in Cooker.	Weight of Food.	Time From	Time To	Condensation.
Turkey and roast beef......	24 lb	10:35 am	11:05 am	2 lb 4½ oz
None		11:05 am	11:17 am	3 lb 7¾ oz
Eggs	4 lb	11:17 am	11:32 am	1 lb 12¾ oz
Potatoes (in for 30 min.)...	50 lb	11:32 am	12:30 pm	25 lb 10½ oz
Beef	6 lb	12:30 pm	12:55 pm	2 lb 5½ oz
Potatoes	14 lb	12:55 pm	1:14 pm	2 lb 5 oz
None		1:14 pm	3:46 pm	3 lb 11½ oz
Potatoes	53 lb	3:46 pm	4:28 pm	19 lb 4½ oz
None		4:28 pm	4:45 pm	2 lb 10½ oz
Milk	13 lb	4:45 pm	4:52 pm	3 lb 3¼ oz
None		4:52 pm	5:43 pm	0 lb 15½ oz
Potatoes	13 lb	5:43 pm	6:18 pm	10 lb 13½ oz
Eggs	4 lb			

FEBRUARY 11, 1913

Food in Cooker.	Weight of Food.	Time From	Time To	Condensation.
Potatoes	101 lb	9:28 am	9:56 am	18 lb 6¼ oz
Str. beans, peas, spinach...	28 lb	9:56 am	10:09 am	7 lb 11½ oz
Potatoes	72 lb			
Potatoes	72 lb	10:09 am	10:20 am	4 lb 12¼ oz
Str. beans, tomatoes, peas..	13 lb			
Milk	18 lb			
Milk	18 lb	10:20 am	10:31 am	2 lb 14¾ oz
Str. beans, tomatoes, peas..	13 lb			
Turkey	9 lb	10:31 am	10:54 am	5 lb 11¼ oz
Sweet potatoes	8 lb			
White potatoes	57 lb			
Turkey	9 lb	10:54 am	11:01 am	1 lb 6¾ oz
Potatoes	22 lb			
		11:01 am	11:27 am	3 lb 2 oz
Potatoes	35 lb	11:37 am	12:43 pm	15 lb 2 oz
		12:43 pm	3:40 pm	14 lb 6¾ oz
Chicken	9 lb	3:40 pm	4:17 pm	11 lb 7¾ oz
Potatoes	10 lb			
Chicken	9 lb	4:17 pm	4:38 pm	1 lb 5¼ oz
		4:38 pm	5:02 pm	2½ oz
Eggs	7 lb	5:02 pm	5:36 pm	3 lb ¾ oz
Potatoes	11 lb			
Potatoes	7 lb	5:36 pm	5:45 pm	9 lb ½ oz

CCCLX.

PRELIMINARY REPORT OF THE COMMITTEE FOR STANDARDIZING A METHOD OF TESTING AIR WASHERS.

ALFRED E. STACEY, JR., CHAIRMAN

OUTLINE OF DATA FOR TESTING AIR WASHERS.

In preparing a code for standard method of testing air washers, the Committee recognized the many difficulties to be encountered, and the large amount of research work necessary. From a review of the work which had been done along these lines, the methods and procedure would naturally arrange themselves in three general groups:

First: Dry Filters.

Second: Soluble Filters.

Third: Direct Dust Count.

The Dry Filter method was the first used and has gone through several stages of development.

First: The plain cloth screen through which all the air passed.

Second: The filter paper method through which passed only a small percentage of the air.

Third: A screen made of cloth having a heavy nap.

Fourth: A fine mesh wire screen.

Fifth: The Carrier Method.

Plain Cloth Screens.

The plain cloth screens were built of cheese or bolting cloth, mounted on light frames and arranged so that all the air passing through the air washers would pass through the cloth. One set was mounted directly after the eliminator plates, and a known amount

of testing material was introduced into the inlet of the washer in a specified time. The percentage by weight of the amount deposited on the cloth to the amount introduced was considered as the washing efficiency of the air washer. The method was later varied by making tests at each end of the washer and not using any special testing material. In this method many inaccuracies from many sources were apt to be introduced.

First: A great number of fine dust particles passed through the screen. This can be readily understood when we recall that ten million dust particles per cubic foot of air is not uncommon, and that one of Dr. Hill's tests made in the middle of Lake Michigan showed six hundred and forty-six thousand dust particles per cubic foot. A cloth with mesh fine enough to remove these would be impractical, if not impossible.

Second: The accuracy of weighing the cloth before and after being exposed gave very unsatisfactory results. The common method was to weigh the cloth before the test, after it had been subjected to a high temperature for a specified length of time. This was again done after the cloth had been exposed to the air to be tested. The accuracy of the results depended largely upon the precision with which the weighing was done.

It is very difficult in varying atmospheric conditions to weigh cloth with extreme accuracy. This is due to the fact that all fabrics have a natural moisture content corresponding to the temperature and relative humidity. As soon as the screen is removed from the oven it starts to absorb moisture to its natural amount and during this time the weight is constantly changing. The atmospheric conditions before and after the test would hardly be the same, so an error due to the different amount of moisture would be introduced. Another trouble experienced is in protecting the screens from outside influences, such as dust being deposited before and after the test is run and dust being shaken from the surfaces during the baking.

Another inaccuracy in weighing, when no special testing material is used, is due to the loss of weight of the foreign matter itself, as a result of its subjection to a high temperature. The smaller the deposit on the screen, the greater the percentage error would be. This would not be so noticeable should testing material be used, but then other difficulties would be met, such as obtaining an even distribution over the face of the washer and keeping the particles divided, which otherwise, from their own weight would fall to

the bottom of the washer. The popularity of this method is due to the simplicity of the apparatus and the natural adaptation of the filter screens which air washers replaced.

In order to overcome to a large extent many of the above mentioned difficulties, this method was refined. Large filter papers, mounted in a funnel, were attached to the suction side of a gas meter. Measured amounts of air were drawn through the filter, and the amount of dust deposited determined by weight. The same error given above, such as weighing foreign dust, etc., were encountered to a smaller extent. Samples were taken at each end of the washer, but no effort was made to get an average air sample over the face of the washer.

A Screen Made of Gloth With a Heavy Nap:

Another variation of the cloth screen method was the substitution of a cloth with a nap for the cheese or bolting cloth. This gave a larger surface, in proportion to the area, for the dust to adhere to, and no doubt cut down the amount passing through the screen.

A Wire Screen:

One trouble experienced with the screen method was in cutting down the air supply. This was caused from the extra resistance to the flow of air. In some instances this could be overcome by varying the speed of the fan. To simplify accurate weighing, wire screen of very fine mesh was substituted for cloth. In this way errors resulting from natural moisture regain were eliminated; however a larger number of dust particles passed through the wire screen, so that the advantage of accurate weighing was more than offset by this greater error.

DESCRIPTION OF THE CARRIER DRY FILTER.

The Carrier Dry Filter consists of two cloth filter bags of small size, through which the air is drawn simultaneously from the front and the back of the washer at an equal and constant rate. This is accomplished by maintaining a constant pressure drop through an orifice in the diaphragm. The pressure difference on this orifice is maintained automatically by means of a throttle valve, controlled electrically through a float in pressure gauge. The entire apparatus is mounted on a subbase 3 feet long and 17 inches wide. The air is taken into each filter bag through a sampling tube, which has openings distributed as uniformly as possible over the faces of the washer. At the point of entrance to the sampling tube, there is an

electric heater, so that the air is thoroughly dried out before passing into the bags. This is done in order that any moisture in the dust or air will not cause deposits on the tubing or choke up the filter bag. This apparatus is very complete and convenient to use, inasmuch as it is self contained. At the time of writing no tests had been made with it. A great advantage of this machine is the possibility of taking samples of air from both sides of the washer simultaneously.

Filters Soluble in Water:

The second general group is composed of filters soluble in water. The only one of this type is briefly described by Dr. Hill in his paper, "Report of Ventilation Division, Chicago Health Department," as follows: The Sugar Filter Apparatus consists of a gas meter through which the air is drawn by means of a high pressure centrifugal fan. On the inlet of the meter is situated the filter, which consists of a glass receptacle containing 25 grains of sugar on a No. 100 mesh wire gauge. From 10 to 50 cubic feet of air are drawn through the sugar, which is then dissolved in 100 c.c. of distilled water, and the dust particles counted in a Sedgwick-Rafter Counting Cell, with a ruled eye piece. For a more detailed description refer to the above mentioned paper. From the Engineer's standpoint this method would never be practical, inasmuch as for accurate results, the services of a chemist are needed. Other substances for the filter besides sugar are used in this type of machine.

Dust Determination By Direct Dust Count:

Under group III, Dust Determination by Direct Dust Count, there is only one method which has been tested and proven satisfactory. This is by the Aitken Dust Counter. Professor Aitken developed this apparatus from his Koniscope, the accuracy of the results depending largely upon the skill of the operator. The air to be tested is drawn into a chamber and expanded adiabatically, thus obtaining saturation. The dust particles in a saturated atmosphere form a cloud or fog, the density of which is compared with standard cards, on which are marked the corresponding number of dust particles per cubic foot. This method leaves much to be desired, as so much depends on the personal element, and there is no way of obtaining a permanent record.

The Aitken Dust Counter overcome the difficulties of the Koniscope by introducing a low power microscope with a ruled object glass. The dust particles falling on this can be easily seen and counted. Briefly, the Aitken Dust Counter consists of a cotton

filter through which air can be drawn to scour the testing chamber. Three way cocks are inserted in the line between the filter and the chamber. These are so arranged as to make possible different dilutions of the air to be tested with the filtered air. The cubical content of the expansion chamber is exactly 50 cubic centimeters and contained in the chamber there is a fibre member for supplying the necessary moisture to saturate the air. Mounted inside this chamber is a small arm for stirring the air so as to obtain a thorough mixture of the test air and the filtered air to accelerate saturation. Between the lens and the ruled object glass, which is situated in the bottom, there is exactly one cubic centimeter; therefore the dust deposited on the object glass is from one cubic centimeter. A displacement pump is connected to one side of the expansion chamber.

In operating, the pump draws the air through a filter for scouring out the expansion chamber; afterwards the air for testing is drawn into the chamber, and the air cock closed. Then the pump is again actuated so as to remove the air from the expansion chamber and draw in the air to be tested. This air is expanded adiabatically by further movements of the pump. The mixing rod in the chamber is agitated before these final movements of the pump. As soon as the air becomes saturated, the dust particles fall upon the object glass, and can be counted through the eye piece. In order to obtain a permanent record, Mr. Hoskins suggested that a small piece of smoked glass, the diameter of the object glass, be introduced into the chamber. The dust particles, in falling upon this, produce minute dots in the carbon. The glass is then removed and mounted for counting on a regular microscope slide. In this manner, a permanent record is made of the results. As far as is known now, the Aitken Dust Counter gives extremely accurate results, although questions have arisen as to the probability of certain gases causing precipitation on the object glass in a saturated atmosphere. As yet this has not been proven.

Dr. Hill is developing a Diffractoscope which consists of a cylinder having a slot on one side through which enters a beam of light, and at one end an eye piece through which observations can be made. The object of this apparatus is to determine the number of dust particles in the air when it is "optically empty," and to use this as a standard for Pure Air. Filtered air will be drawn into the chamber until it is optically empty, that is until no dust particles are visible in the beam of light, then by means of the Aitken Dust Counter, the dust particles remaining will be determined.

Another method, which has not as yet been experimented with, consists of a high grade camera, having high speed shutters and microscopic lenses. With a standard ray of light, photographs can be made directly in the air chamber. This apparatus will give a permanent record of the dust count, and in all probability with standard lens and standard beam of light, dust counts can be made with the same degree of accuracy.

Data to be Obtained from Tests:

In determining a procedure to follow in our testing, it was found necessary to consider the following:

First: How many hours after a heavy rain that a test should be run?

A heavy rain acts as an air washer and removes from the air all but traces of dust. This has been proven conclusively by daily readings taken on the roof of the Chicago City Hall. As the dust remaining in the air would be, necessarily, very difficult to remove, an air washer tested under these conditions would be at a great disadvantage, and would not show a true average result of the washing efficiency.

Second: Would it be desirable from the standpoint of the Engineer to have two washing efficiency guarantees; one covering the removal of dust which has an affinity for water, and the other the removal of particles of carbon and oil?

Under the first head would come dust from the streets, which is composed of vegetable matter, dust from the pavements, particles of hair, etc. It may be possible to find a method to differentiate between these two kinds of dust.

Third: Would it be desirable to test all washers with some standard material?

A great many questions rise in connection with this, such as percentage of foreign material to the pounds of air passing through the washer, the method of introducing the material into the air, and also the nature of the material.

Fourth: What correction should be made in the washing guarantees for variation in temperature and relative humidity?

Experiments no doubt will prove a wide variation of washing efficiency, when operating under different temperatures and relative humidities. This variation will no doubt be due to the ease of removing dust which has an affinity for water when the air is near the saturation point, as a great amount of this would be precipitated from its own weight.

Fifth: Does the temperature of the spray water in relation to the wet bulb temperature of the entering air have any effect on the washing efficiency?

We might expect when any dehumidifying is done to find 100 per cent. washing efficiency, in case the elimination of free moisture is perfect. The effect on the washing efficiency of heating spray water is not known, and will have to be investigated.

Sixth: What procedure should be followed in finding the efficiency of a washer for bacteria removal?

This point is of great importance, as people are becoming educated in regard to bacteria in their homes, schools, churches, theatres and manufacturing places. As the work progresses, other questions of equal importance will present themselves.

Experimental Apparatus and Procedure:

In order to do the research work necessary to obtain the data for a basis on which to formulate recommendations for a standard method of testing air washers, your Committee considered it necessary to have an experimental plant so that all the variables could be controlled. The Carrier Air Conditioning Company placed at their disposal one of its type "H" Air Washers and Humidifiers, connected to a Buffalo Niagara Conoidal Fan. The fan and recirculating pump are driven by General Electric Motors. In connection with the Carrier Air Washer, there is furnished two sets of eliminator plates of different types, one having a device for flooding the surfaces and six corrugations, and the other without a flooding device and with four corrugations. There are also two sets of spray nozzles of different sizes. This apparatus has been installed in a pent house on the roof of the Chicago City Hall Building.

The first tests will be run under as nearly constant conditions as possible to determine the comparative accuracies of the different methods of dust determination. After this has been established, tests will be run varying one atmospheric condition at a time, so that its effect can be studied. Later different types of dust will be introduced and their effect on the washing efficiency noted. Tests will be run with different temperatures of the spray water, which can be held constant by a Carrier Automatic Dew Point Control. Bacteria plates will be taken in connection with the foregoing, both in the air and the recirculating water. From chemical analysis of the recirculating water, data on the composition of the dust particles will be obtained.

The Committee is attempting to collect complete and accurate data to establish the laws governing the efficiency of air washers, and with these as a foundation, recommendations for a Standard Method of Testing can be formulated and submitted for your approval. Data obtained from these tests will be reported at the winter meeting.

Respectfully submitted,

Alfred E. Stacey, Jr.,
Dr. E. Vernon Hill,
Harry M. Hart,
Committee.

DISCUSSION

Mr. Braemer: I have heard with a great deal of interest the report of the above Committee and desire to say that this is a very important and timely subject, since the air cleansing guarantees in connection with air washers, as at present made by different manufacturers, are subject to criticism, to say the least.

Our company has for a number of years past conducted numerous tests in our experimental laboratory for the purpose of determining upon the best method of testing air washers, but each and every one so far has proven unsatisfactory in one way or another. We have in many cases endeavored to ascertain the cleansing efficiency by weighing a cheesecloth screen, subjected to the air before and after leaving the air washer, and this test is, in the writer's opinion, an utter failure since the amount of dirt collected on the screen in the air leaving the air washer was so small as to make practically no difference in the weight, but such difference as existed would appear due to the avidity of the cheesecloth for the moisture absorption.

Sometimes the above tests were conducted for a period of several hours without adding any dirt to the air in passing artificially; at other times we have taken a flour sifter holding about two quarts of flue dust and passed it through the air washer, but with the same result in both cases. We have used dry cheesecloth screens, several screens placed in succession in front of the air washer and of course fine dust particles would pass through the screens, at the same time if very much passes through there is no doubt about it but that the screen will be

discolored, and the screens thus placed would give a fair indication of the air cleansing efficiency of the washer as compared with the similar screen placed in front of the washer. At other times we have placed a blacksmith forge in front of the air washer, built a heavy, soft coal fire, placed oily waste on the fire and a cheesecloth screen placed beyond eliminator of the air washer would indicate by discoloration the amount of carbon or dirt passing through and by a person standing in front of the eliminators a fair idea could be gotten as to the removal of the gases.

Another method we have pursued in many cases and which seemed so far the most satisfactory as an ocular demonstration, we have called it the Webster method and it consists of the placing of one or more small screens in the path of the air before and after leaving the washer. These cheesecloth screens were given a coat of vaseline, with the object of making the dirt adhere to the screens, and in such cases it was found after a day's run that the screens in the fresh air inlet would be absolutely coal black, whereas the screens in the air leaving the air washer were in some cases entirely clean and in others slightly discolored. Of course such a test gives no accurate method of establishing the efficiency of the air washer, but it indicates nevertheless in a very satisfactory way whether the air washer is doing good work or not. This test of course is only satisfactory under natural conditions.

From our experiments as well as our actual experience in many and varied installations, we have found a difference in the air cleansing efficiency with a given air washer for different temperature and humidity conditions; for instance, we have found when the water used in the air washer under natural conditions was very cold the air cleansing efficiency was not as good as when the water was of a higher temperature and this is accounted for by the low wet-bulb temperature of the entering air and consequent low relative humidity of both air entering and leaving. In some instances the writer has advised making provision for warming the water slightly in order to increase the air cleansing efficiency of the washer.

The subject is a very broad one since a great many variables enter into the question, but it seems to the writer that any standard method of testing air washers for air cleansing efficiency should be made with a view toward simplicity. Not only should a standard method be established, but a standard con-

dition, and this condition should be the worst one found after a series of tests.

In the report by the Committee, under the heading of "Data to be Obtained from Tests" is stated:—1st: How many hours after a heavy rain that a test should be run? This, naturally would be assuming that the test should be run without passing artificially any dirt through the washer, but under natural conditions, whether it has recently rained or not, would have little or no influence on an air washer test conducted by introducing dirt artificially into the air passing. 2nd: Whether or not it will be desirable from the standpoint of the engineer to have two washing efficiency guarantees, one covering removal of dust which has affinity for water and the other the removal of carbon and oil, would say that if an air washer will remove a certain satisfactory percentage of carbon or oil it is sure to remove practically all matter with affinity for water, so that if a series of tests were conducted covering relative efficiency of the air washers for removal of both matter with affinity for water as well as carbon, etc., a standard guarantee with reference to one could be adopted which would cover both. 3rd: Whether or not it will be desirable to test the air washer with standard material, the writer would say, positively yes; at the present time tests with different air washers are conducted with different materials, some use road dust, others wood ashes, others lamp black, etc. We have for several years past used flue dust removed from our smoke stack at our factory where we burn soft coal in the boilers and we believe this material representative for the purpose. It probably would be a difficult matter to find a standard material which would be within the reach of everybody, yet such a thing might no doubt be done. 4th: What correction should be made in the washing guarantees for variation in temperature and relative humidity? In this connection would say that it does not seem to be to the writer that such corrections should be necessary, since our experience indicates that the air cleansing efficiency remains reasonably constant for a fair range in temperature and humidity, and it is only when the outside wet-bulb temperature has been very low with a consequent low temperature of wash water, no humidity control system being installed, that we have seen any material difference in the results, so that if air washer tests were conducted with ordinary conditions of temperature and humidity, it seems to the writer that would be sufficient.

5th: Does the temperature of the spray water in relation to the wet-bulb temperature of the entering air have any effect on the washing efficiency? This seems to be substantially the same as covered by question 4. When de-humidifying is done of course conditions are different, inasmuch as in such cases the wet-bulb temperature of the air entering the washer is usually high and therefore the air leaving the air washer is completely or practically saturated, and a high air cleansing efficiency might be expected. The 6th question, with reference to bacteria removal, is a question for scientists and not engineers to solve. Bacteriological tests in connection with air washers were made at the Springfield International Y. M. C. A., and Dr. McCurdy of that Institution and Mr. D. D. Kimball who was the Consulting Engineer, will be able to tell us how these tests were conducted.

Summing up the above the writer would suggest:—

1st. That endeavors be made towards establishing a standard method of testing air washers for cleansing efficiency—after careful investigation by the Committee.

2nd. That endeavors be made towards establishing a standard condition under which air washers should be tested for air cleansing; this condition referring to range of temperature and humidity and spray chamber velocity of, for instance, 500 feet per minute.

3rd. That endeavors be made towards determining upon a standard material for testing air washers with reference to air cleansing. This material should be as near as possible that ordinarily found in outside air, such as, for instance, flue dust or road dust or a combination as may be determined upon.

4th. That endeavors be made toward determining upon a standard quantity of the testing material selected per pound of air handled.

The writer thinks that tests made with the experimental air washer by the Committee should enable it in due time to arrive at the most desirable standards, but we must not lose sight of a fact which must be potent to any one who has studied the question, that the air cleansing efficiency of an air washer very greatly depends upon the design of the two principal factors of air washing, namely, the eliminator and the spray. An eliminator of a given type with six deflections obviously gives greater eliminating efficiency than an eliminator of the same type with

only four deflections, but an eliminator with four deflections of another type might give as good or better eliminating results than the first type of eliminator mentioned with six deflections. Experiments in our Laboratory have shown us conclusively that eliminators constructed on the basis of having continuous zig-zag passages for the air with small lips on the baffles are less efficient than eliminators with staggered rows of baffles. Experiments have further proven to us that it is entirely possible by the use of staggered rows of eliminators with four deflections of proper design to get complete removal of the free moisture, to have an exceedingly low resistance to the air in passing and with a high air cleansing efficiency, so that in establishing a standard air cleansing guarantee, tests should be made with eliminators of other types in addition to those now used by the Committee, and our Company will be glad to place at the disposal of the Committee an air washer for this purpose and we will equip this air washer with three types of eliminators. In our extensive experience in this line of business we have found that no cure-all can be found in eliminators as in anything else; eliminators must be built specifically for the purpose intended, and thus our Company has three types of eliminators, depending upon the work they are to perform.

As above stated our Company will be very glad to offer an air washer to the Committee for the purpose mentioned and the writer will be glad to discuss the question with them.

Mr. A. E. Stacey, Jr.: It might be interesting to know that there have been tests made on the roof of the Chicago City Hall and the lowest dust count recorded at about 18,000 per c.c. I omitted making a note here that these Carrier sample bags are placed in an oven where they are dried so that there is no moisture regain. When this preliminary data has been obtained from tests, we will find other questions very important to be answered. We are now trying to separate the different kinds of dust and find their chemical characteristics by analysis.

Mr. D. M. Luehrs: The American Blower Company realizing the importance of this testing work, have gotten together some apparatus, practically the same as used by the Committee, and are going after this air washer testing thoroughly. I have with me some photographs of the Aiken Dust Counter, and the other apparatus. We also have several ideas that are at variance with the Aiken Dust Counter that we are going to thrash out.

We do not believe that the Aiken Dust Counter as at present used is sufficiently accurate for air washer testing.

President Lewis: The Committee is anxious to receive any suggestions possible to enable them to make a full report at the annual meeting.

Mr. Thomas Tait: I might make one recommendation. I believe that that paper would be more valuable if there were four or five photographs accompanying it of the apparatus mentioned.

Mr. A. E. Stacey, Jr.: A large number of photographs of that apparatus have already been printed in Dr. Hill's paper presented last winter at the annual meeting. The Aiken Dust Counter is not included in the photographs, because we did not have time to get copies made for this paper.

President Lewis: I am very proud of the attitude which the manufacturers of air washers have taken in this matter. I think it assures a most encouraging outlook for the future of our Society that these people under the stress of competition should so frankly give us the benefit of their experience and information; and I believe that the Committee would be very glad indeed to have sample apparatus and suggestions from all manufacturers sent to them so that they may be tested in the plant in Chicago and at such tests the Committee will be glad to have representatives of manufacturers present; not that the Report of the Committee will be permitted to show the advantages of any one manufacturer over another, but in order that the general information which we are sadly deficient in may be obtained.

Mr. Daniel M. Luehrs: Sometime ago I went to Chicago to see Doctor Hill to learn what work they were doing. It was our idea, seconded by Doctor Hill, that we conduct these experiments on the same line that was being followed by the Committee, in order to get an outside check by an independent force of observers. The American Blower Company has quite a testing crew, and they intend to devote that crew to the service of making these air washer tests during the coming year, to see if we can develop an instrument of some kind that an ordinary layman can use as a testing instrument. Doctor Price of the Detroit Board of Health has offered to co-operate with us on the bacteriological work, and also to check our microscopical work on dust counts in order to be sure that we are following

a correct method of procedure. Of course we are only too anxious to co-operate with the Committee of the Society in developing facts that are of value.

Willis H. Carrier: There is one item that I noted in Mr. Braemer's discussion to which I would like to call attention, viz.: the use of screens covered with vaseline or glycerine as an indication of the amount of dirt passing through a washer. I note that Mr. Braemer states that it has been his experience that a screen that was very open would show very much more dirt, especially fine dirt like smoke, than one that was of closer mesh. In this I quite agree with Mr. Braemer. We know for instance that if a cheese cloth screen and a pocket handkerchief be exposed to the same current of air that the cheese cloth screen will quickly show signs of soil while the pocket handkerchief being of closer weave will remain apparently clean. This is entirely due to the fact that the air passes through the cheese cloth screen much more readily than through the handkerchief. The heavier particles may impinge on the handkerchief without adhering while the lighter particles having so much less inertia are diverted by the air current before touching the handkerchief. From this it would seem that a screen covered with vaseline would only catch the heavier particles while the lighter particles would tend to dodge around it. Such a test applied to an air washer would appear only to be an indication of removal of the heavier particles of dirt.

Mr. Wm. G. Braemer: I agree with Mr. Carrier that if a cheese cloth screen is covered with vaseline to such an extent that it is made solid, so that no air can pass through, an air cushion will be formed and the air will be deflected on the sides. The point is to put only a very small quantity of vaseline on the cheese cloth, just enough to cause the dust to adhere to it. However, assuming that such an air cushion is formed, if there is any dirt in the air, it will discolor the screen.

Mr. Daniel M. Luehrs: We find in the use of screens in some localities in testing air washers, they will get very black; in other cases where you have a different kind of dust in the air there will only be a light deposit on the screen. While there may be a greater efficiency of dust cleaning in the first case, yet you do not get the same amount of color in the second instance because of the difference in the quality of the dust.

Mr. Wm. G. Braemer: Another point that I want to bring out is that we will probably never be able to completely remove

all dust particles from the air by passing it through an air washer; but if we can remove the dirty dust particles I do not know that there will be any harm in leaving a small percentage of the fine clean dust particles. I have not mentioned the Aiken Dust Counter thus far, for the reason that I know very little about it. I understand from the reports I have received from our Chicago office that the air samples used in connection with the dust counter were so small as to make the test of little value in its present form. I am going to Chicago after this meeting is concluded for the specific purpose of having a talk with Doctor Hill about the matter and to become acquainted with the Aiken Dust Counter and its use.

Mr. A. E. Stacey, Jr.: I think Mr. Braemer does not understand that a sample is taken over the entire face of the washer, and then the sample for the dust counter is taken from this larger sample. One inaccuracy that we do not know about in the Aiken Dust Counter which appeals to us just now is as to whether or not certain gases make a precipitation on the plate. This question has been brought up, but has not as yet been proven.

Secretary Blackmore: I know more about washing clothes than I do about washing air; but it seems to me if I was going to make a demonstration as to how clean I could wash clothes I would not put a whole lot of dirt on them first in order to demonstrate by the dirty condition of the water that the clothes must be clean. Mr. Stacey and his committee have gone into this question very much in the way that I would expect them to, and Mr. Stacey has explained the plan by which they will work out the problem and that leaves very little for the rest of us to offer. It seems to me the way to go about this problem, whether or not you employ a diffractiscope, is to find out what is left in the air after it is optically empty, and see whether the number of dust counts that then remain in it are injurious. If not, that can be accepted as the standard limit of the number of dust counts that can be allowed for pure air. The optically empty air should be searched very carefully to see if any bacteria remain in it, and if so, they should devise means to remove them and in this way formulate a standard of purity. Just how dirty you could make the screens after you have finished an operation would not interest me a particle, but how pure the air is after it has gone through the washer, and how free it is

from injurious bacteria is important. Dame Nature has kept us so long in our environment that we have acquired guards that protect us against dust to a certain extent.

I think the diffractiscope and the Aiken Dust Counter will prove to be good instruments, but I believe the telescopic camera when properly developed will prove to be a more accurate instrument for registering dust count.

Mr. Wm. G. Braemer: I have no doubt that the use of the diffractiscope and the Aiken Dust Counter, or a combination of both, will be satisfactory for testing purposes after methods of application have been properly developed, especially in testing plants and laboratories, but at the same time we should not lose sight of the fact that the use of such instruments is not always convenient or possible in actual installations. I think we should endeavor to establish a plain and simple standard method of testing air washers for cleansing efficiency which can be readily applied by engineers or manufacturers' representatives on the ground. An occular demonstration such as the "Webster" method mentioned in my written discussion has proven effective and convincing wherever applied.

J. Irvine Lyle: I would disagree with Mr. Braemer's last statement. I think what we need is technical accuracy. We do not want any more guess-work such as has characterized the methods that have been followed a great many years. At the Carrier factory we have been trying for the last three or four years to test air washers. The more tests that we have carried on the more we have realized our ignorance. Professor Busey had been working on this problem for eighteen months previous to his death, and from his own statement he had arrived nowhere. We hope to continue that work. But I do not want Mr. Braemer's recommendations to go by the board, I do not want him to feel that the Carrier Company is trying to monopolize the tests in Chicago. On October 1st we are going to need the apparatus that is out there for other work, and I would like to have Mr. Braemer have his apparatus sent out to Chicago before October 1st, that it may be also tested.

Mr. Wm. G. Braemer: I agree absolutely with Mr. Lyle as to the necessity for accuracy rather than slipshod methods and guesswork; but I can see no reason why it would not be possible for us to establish a simple method for testing air washers that shall at the same time be accurate.

Mr. Theo. Weinshank: I am a novice in air washer engineering, having only 14 years' experience but I want to substantiate the statement made by Mr. Lyle as far as bacteria is concerned and what he said about guess-work, also the statement made by Doctor Hill at the last annual meeting as to deductions made from observations. With air washers we can accomplish that for which they are designed, namely, wash the air, that is: remove dust, fumes, smoke, and even odors; but when the question of bacteria is reached, then allow me to cite you an experience I had about fourteen years ago at the Union Stock Yards at Chicago where they were making a kind of sausage called "Summer Sausage." This summer sausage was dried in a specially prepared room, not by heat but by exposure to the atmosphere. On the outer skin of the sausage there developed a white mould, and I was informed by the chemist that this was due to a microbe from the dust in the atmosphere. I suggested to him that he try getting the dust out of the air with a fan and air washer. He thought it was a good idea and went to the expense of equipping the place, putting in a fan and an air washer, and washed the air completely so that there was no dust nor dirt going through. The chemist then thought that we had the problem solved and put in a batch of sausage to try it out. When the sausage came out it was absolutely white, the bacteria were multiplied a million fold. Now whether the bacteria came from the air, from the water or from the sausage we could not decide. The fact remained that the bacteria were not eliminated. The chemist said, "I can get up something that will kill the bacteria, but I will kill the life in the sausage when I do it." So I believe we can kill the bacteria in the air of our school houses, but whether at the same time we will not kill off the children is the question.

REPORT OF THE CHICAGO COMMISSION ON VENTILATION

The Chicago Commission on Ventilation is a delegated, voluntary organization, composed of representation from the Department of Health of the City of Chicago; representation from the Chicago Public Schools; representation from the A. S. of H. & V. E.; representation from the Chicago Architects Business Association; representation from the Illinois Chapter of the American Institute of Architects; representation from the Western Society of Engineers.

The Commission is now in its fourth year and the demand has been so great for information concerning its work that they have felt it necessary to publish a pamphlet on the organization and its work. This publication will be ready for distribution in a few weeks and embodies quite an extensive report of the Commission along four general lines, as follows:—

(1) A complete history of the organization including a statement of its methods and working principles.

(2) The opinion of the Commission on different phases of ventilation.

(3) A statement of some of the problems at present being undertaken by the Commission.

(4) Excerpts from addresses or papers given by different members of the Commission.

The organizations holding membership in the Commission are sufficiently established and also sufficiently varied in their purposes to bespeak the value of its findings. It is but fair also to state that almost all of the resolutions embodied in their publication have been the subject of careful observation or experimentation by members of the Commission.

The past season has been devoted to testing different systems of ventilation in theatres, schools and street cars. One test was made of a large, general office and five tests have been made in our cabinet.

In theatre tests, the following observations are made:—Type of theatre, Seating capacity, System of Heating, System of Ventilation, Location of Fresh Air Intake, Type and capacity of supply and exhaust fans, Number, Size and location of inlet and outlet openings, Type and capacity of boiler or furnace. Tests are made of the air velocities, air movements, CO_2, Bacteria, Dust, outside and inside temperatures and relative humidity. When theatres are unoccupied, lighted, standardized candles are placed in the seats.

Observations in school rooms and street cars are about the same except that during the street car tests, the speed and direction in which the car is running and the velocity and direction of wind is also noted.

For the cabinet tests, the following observations are made:—Sex, age, weight, height, type, occupation and present condition of the subjects. A careful record is kept of the temperature,

Relative Humidity, CO_2, Oxygen, Nitrogen, Bacteria, Dust and Air changes. A careful record is also kept of the Pulse, Blood Pressure, Temperature, Respiration, general appearance and general feeling of the subjects.

It is hoped that the first publication of the Commission will be of sufficient benefit to the public to warrant further work along the same lines.

Respectfully submitted,

H. M. HART.

In Memoriam

	Joined the Society	Died
L. H. Hart, New York................	Sept. 1894	Jan. 26, 1897
James W. Gifford, Attleboro, Mass.....	Jan. 1898	July 26, 1899
William McMannis, New York........	Sept. 1894	Jan. 19, 1901
Charles F. Tay, San Francisco, Cal....	Jan. 1896	Sept. 8, 1901
Arthur H. Fowler, Philadelphia, Pa....	Jan. 1897	June 3, 1903
Stephen G. Clark, New York.........	Dec. 1902	Feb. 3, 1904
Charles M. Wilkes, Chicago, Ill......	Jan. 1897	Jan. 7, 1905
James Curran, New York............	Dec. 1901	Oct. 27, 1905
Herbert W. Nowell, New York........	June 1904	Mar. 25, 1905
Enoch Rutzler, New York............	July 1901	Feb. 29, 1908
Harry J. Ott, Chicago, Ill.............	Dec. 1906	Sept. 25, 1908
Thomas J. Waters, Chicago, Ill.......	Sept. 1894	Feb. 25, 1909
Max J. Mulhall, New York..........	June 1909	July 30, 1909
Walter B. Pelton, Dorchester, Mass...	June 1910	Nov. 2, 1910
R. Barnard Talcott, Denver, Colo.....	June 1899	Dec. 4, 1910
William H. Bryan, St. Louis, Mo.....	July 1898	Dec. 8, 1910
James R. Wade, St. Louis, Mo.........	Dec. 1909	Mar. 9, 1911
James Mackay, Chicago, Ill...........	Sept. 1894	July 18, 1911
Warren S. Johnson, Milwaukee, Wis..	Jan. 1906	Dec. 5, 1911
W. C. Bryant, Holton, Kan............	Jan. 1901	April 6, 1912
H. A. Joslin, Boston, Mass............	Jan. 1896	Oct. 3, 1912
Andrew Harvey, Detroit, Mich........	Jan. 1896	Oct. 9, 1912
N. P. Andrus, Brooklyn, N. Y.........	Sept. 1894	Jan. 13, 1913
J. A. Payne, Jersey City, N. J..........	Sept. 1894	Mar. 3, 1913
J. S. Billings, New York	Jan. 1896	Mar. 10, 1913
Wiltsie F. Wolfe, Philadelphia, Pa....	Sept. 1894	Dec. 4, 1913
R. C. Clarkson, Philadelphia, Pa......	Sept. 1894	Dec. 26, 1913
H. W. E. Muellenbach, Hamburg, Ger.	July 1903	April 17, 1914
W. A. Gates, Oklahoma City, Okla.....	July 1907	May 24, 1914
F. L. Busey, Buffalo, N. Y.............	Sept. 1911	June 7, 1914
E. B. Denny, Newark, N. J.	Jan. 1906	July 12, 1914
A. B. Franklin, Boston, Mass.........	June 1902	Aug. 22, 1914

CHARTER

State of New York,
City and County of New York. } ss.

We, the undersigned, of full age, and citizens of the United States, and a majority of whom are citizens of and residents in the State of New York, being desirous of forming a society for the purpose hereinafter set forth, in pursuance of and in conformity with an Act of the Legislature of the State of New York, entitled, "An Act for the Incorporation of societies or clubs for certain lawful purposes," passed May 12th, 1875, and the several Acts amendatory thereof and supplemental thereto, do hereby certify and declare as follows:

I.—The corporate name of the society is to be known as The American Society of Heating and Ventilating Engineers.

II.—The particular nature and objects for which said society is formed are:

1. The promotion of the arts and sciences connected with heating and ventilation, and the encouragement of good fellowship among its members.

2. Improvement in the mechanical construction of the various apparatus used for heating and ventilation.

3. The maintenance of a high professional standard among heating and ventilating engineers.

4. To establish a clearly defined minimum standard of heating and ventilation for all classes of buildings.

5. To favor legislation compelling the ventilation of all public buildings in accordance with the standard of the Society.

6. To encourage legislation favorable to improvement in the arts of heating and ventilation, and to oppose legislation inimical to the business of the engineer.

7. The reading, discussion and publication of professional papers, and the interchange of knowledge and experience among its members.

8. To establish a uniform scale of prices for all professional services.

III.—The number of directors and managers of said society shall be seven, and the names of such directors and managers for the first year of its existence are:

Charles W. Newton, Baltimore, Md.
James A. Harding, Boston, Mass.
George B. Cobb, New York City.
William McMannis, New York City.
Benj. F. Stangland, New York City.
Louis H. Hart, New York City.
Ulysses G. Scollay, Brooklyn, N. Y.

IV.—The principal place of business or office of said Society is to be in the City and County of New York.

In WITNESS THEREOF, We have made and signed this certificate in duplicate and have hereunto set our hands and seals at the City of New York, this 23rd day of January, A. D., eighteen hundred and ninety-five.

W. M. MACKAY,
JAMES A. HARDING,
GEORGE B. COBB,
[L. S.] WILLIAM MCMANNIS,
B. F. STANGLAND,
L. H. HART,
U. G. SCOLLAY.

State of New York,
City and County of New York, } ss.

On this 23rd day of January, A. D., eighteen hundred and ninety-five appeared before me personally WILLIAM M. MACKAY, JAMES A. HARDING, GEORGE B. COBB, WILLIAM McMANNIS, BENJ. F. STANGLAND, LOUIS H. HART and ULYSSES G. SCOLLAY, all to me personally described known, and known to me to be the individuals described in and who executed the foregoing instrument, and they severally and duly acknowledge to me that they executed the same.

FRANCIS W. HOADLING,
Notary Public No. 118,
[L. S.] New York County.

I, C. H. Van Brunt, a Justice of the Supreme Court of the State of New York, of the First Judicial District, in which the principal place of business of the aforesaid society is located, do hereby approve of the form and sufficiency of the foregoing Certificate of Incorporation and consent that the same be filed.

Dated N. Y. City, January 24th, 1895.

[Signed] C. H. VAN BRUNT,
J. S. C.

CONSTITUTION AND BY-LAWS

The American Society of Heating and Ventilating Engineers

ARTICLE I.

NAME AND OBJECT.

Section 1. The name of this organization shall be The American Society of Heating and Ventilating Engineers.

Its objects shall be the promotion of the arts and sciences connected with Heating and Ventilating in all branches; the maintenance of a high professional standard among its members; the reading, discussion and publication of professional papers which are calculated to advance the science of Heating and Ventilation; and the interchange of experience among members.

Sec. 2. The headquarters of this Society shall be located in the city of New York.

ARTICLE II.

MEETINGS.

Section 1. All business meetings of this Society shall be held in New York City. The annual meeting shall begin on the third Tuesday in January of each year, and continue from day to day as the Council may arrange. Special meetings may be called at any time at the discretion of the Council, or shall be called upon the written request of twenty (20) members.

Sec. 2. Professional sessions for the reading and discussion of papers, reports of committees, etc., shall be held at least twice a year. The time and places of holding such sessions shall be determined by the Council at least sixty (60) days prior to the dates selected.

Sec. 3. Fifteen members present shall constitute a quorum.

ARTICLE III.

MEMBERSHIP.

Section 1. This Society shall be composed of members, junior members, associate members, and honorary members.

Sec. 2. An applicant for membership shall be a Heating or Ventilating Engineer or Expert, who has been professionally engaged in the business of heating and ventilation for at least five years. Graduation from a school of engineering of recognized repute shall be considered as equivalent to two years of active practice. The applicant must be qualified to design as well as take charge of and direct the construction of heating and ventilating work in the branch which he has made his specialty. Mining, civil, electrical, mechanical, naval, or Government engineers, or architects, who are, in the opinion of the Council, qualified by reason of their experience in designing or superintending the installation of heating and ventilating plants, may also become members.

Sec. 3. An applicant for junior membership must have been actively engaged in the work of heating and ventilating for three years, or be a graduate of a school of engineering of recognized repute.

Sec. 4. An applicant for associate membership must have such knowledge of, or connection with the business of heating and ventilating as to qualify him, in the opinion of the Council, to co-operate with heating and ventilating engineers, in the advancement of professional knowledge.

Sec. 5. Honorary membership shall be conferred only on persons who have rendered such eminent service to the science and art of heating and ventilation as shall entitle them, in the opinion of the Council, to this distinction. The number of honorary members shall not exceed five.

Sec. 6. All members, honorary members, juniors and associates shall be equally entitled to the privileges of membership, excepting that honorary members, juniors and associates shall not be entitled to vote or hold any office in the Society.

ARTICLE IV.

ELECTION OF MEMBERS.

Section 1. Every candidate for admission to the Society, except a candidate for honorary membership, must be proposed

by at least two members to whom he should be personally known, and his application must be seconded by two other members. The application for membership must be accompanied by a statement in writing by the candidate of his qualifications for membership, including an account of his professional experience, together with an agreement that he will conform to the requirements of membership if elected.

Sec. 2. Honorary members shall be proposed only at annual meetings, and all proposals must have the unanimous indorsement of the Council before their names are submitted to the meeting for election.

Sec. 3. All applications for membership are to be sent to the Secretary, and acted upon by the Council, at its first meeting thereafter. The Secretary shall mail to each member of the Society, in the form of a letter ballot, the names of candidates who are recommended by the Council for election, together with a statement of their qualifications, and the names of their proposers and seconders.

Sec. 4. Any member entitled to vote will indicate the nature of his vote, whether affirmative or negative by writing the word "Yes" or "No" opposite the name at the point to be provided in the ballot. Each member shall draw a line through the name or names of any or all candidates for whom he does not desire, or does not feel qualified by sufficient acquaintance to vote. The ballot is to be enclosed in two envelopes, the inner one to be blank and the outer one endorsed by the member voting, and returned to the office of the Society within thirty (30) days of its date.

Sec. 5. The said blank envelopes shall be opened by the Council at the first meeting after the thirty days have expired, and the candidates elected shall be notified at once, and their names announced at the ensuing meeting of the Society. The names of candidates not elected shall neither be recorded nor announced in the proceedings.

Sec. 6. If adverse votes to the number of two per cent. of the votes cast, but not less than seven votes, shall be cast against any candidate, his election shall be defeated.

Sec. 7. Any person who shall be elected to membership in the Society shall be promptly notified of the fact by the Secretary, and he shall accept such election, subscribe to the rules of the Society, and pay the initiation fee within three months after

such notice of election shall have been sent him, or his election shall be void.

Sec. 8. The name of any rejected candidate may, after three months from date of such rejection, again be presented to the Council, and if reconsideration is granted, another ballot shall be ordered, at which negative votes to the number of four per cent. of the votes cast, but not less than twelve votes, shall be required to defeat the candidate.

Sec. 9. Junior members desiring to become full members shall make application to the Council, who shall consider the reasons advanced for the change in membership, and if found satisfactory, a favorable vote of the majority of said Council shall be sufficient to authorize the transfer.

ARTICLE V.

INITIATION FEES AND DUES.

The initiation fees of members and associate members shall be $15.00 and of junior members $10.00. The annual dues shall be $10.00 for all grades of members. All dues of present members of all grades shall be payable in January of each year in advance, and for all new members of all grades, the initiation fee and the annual dues for the first year shall be due and payable on the first day of the month following the date of election of such members. The annual dues for each ensuing year shall be due and payable in advance on the corresponding day in each year thereafter. Upon the payment of the initiation fee and the annual dues for the first year, the person elected shall be entitled to the rights and privileges of membership in the grade to which he was elected. The date of payment of a member's annual dues may be changed to the first day of any other month, and a pro rata adjustment of the dues made, by application to the Secretary.

Junior members promoted to full membership shall, upon notification of transfer, pay an initiation fee of $5.00.

ARTICLE VI.

OFFICERS.

Section 1. The affairs of the Society shall be managed by a Council of twelve members, which shall consist of the President of the Society, two Vice-Presidents, eight councilors and a

Treasurer. Four members shall constitute a quorum for the transaction of business. The Secretary may take part in the deliberations of the Council, but shall not have a vote therein.

Sec. 2. The President shall preside at all meetings of the Society, and exercise general supervision over its interests and welfare. He shall also be, by virtue of his office, Chairman of the Council. He shall have power to call special meetings of the Council, if in his judgment the needs of the Society require it, and he shall call special meetings of the Council, when so requested by three members of such Council, or if requested in writing by ten members of the Society. He shall appoint all committees not otherwise provided for in these By-Laws, or by resolutions constituting said committees. He or the First Vice-President shall, with the Treasurer, sign all checks, written contracts or other financial obligations of the Society authorized by the Council, and he shall be ex-officio member of all standing committees.

Sec. 3. In the absence of the President from any meeting of the Society or of the Council, the first or second Vice-President shall be vested with all the powers of the President. In the absence of the President and both Vice-Presidents, the meeting shall elect a temporary presiding officer from the members present; the Secretary calling for a vote.

Sec. 4. The Secretary shall be present at all meetings of the Society and of the Council, and keep the minutes thereof. He shall conduct the routine correspondence, receive all communications addressed to the Society, and present the same to the Society or to the proper officers or committees. He shall issue notices of all meetings, promptly inform committees of their appointment, and officers and new members of their election. He shall keep a complete list of members, with their addresses and dates of election, and shall send a copy thereof annually to each member. He shall render all bills and collect all moneys due the Society, turning the same over to the Treasurer, taking his receipt for the same. He shall have charge of all books, periodicals and drawings and similar property belonging to or loaned to the Society. He shall perform such other duties pertaining to his office as shall be imposed upon him by the Society or by the Council, and shall receive a salary to be fixed by the Council. He shall give a bond for the faithful performance of his duties, in such amount as the Council may require; the premium to be paid by the Society.

Sec. 5. The Treasurer shall receive and have charge of all funds of the Society, and shall deposit the same to the credit of the Society in such depository as may be designated by the Council. He shall pay all bills, duly approved, and shall keep book accounts of all his receipts and expenditures, which shall be at all times open to inspection by the Council. He shall present, at each annual meeting of the Society, a written statement showing the receipts and expenditures during the previous year; which statement must be duly audited by an Auditing Committee, to be appointed by the Council. He shall make reports to the Council as to the financial standing of the Society at any time they may call for it, provided not less than three days' notice shall have been given. He shall give bonds for the faithful performance of his duties, in such amount and with such securities as the Council may require; the premium to be paid by the Society.

Sec. 6. The Council at the first meeting after the annual meeting, shall appoint a member of the Society to serve as Secretary of the Society for one year, subject to removal for cause by vote of the Council at any time after one month's written notice has been given him, to show cause why he should not be removed, and he has been heard in his own defence if he so desire. The Secretary shall receive a salary which shall be fixed by the Council at the time of his appointment. The Council shall have the supervision and care of all of the property of the Society, and shall manage and conduct its affairs in accordance with the charter and constitution. They shall hold stated meetings, at least once every two months, the first meeting to be held within ten days after the annual meeting, and special meetings at the written request of three members of the Council or upon the call of the President. They shall present at the first session of the annual meeting of the Society, a general statement of its proceedings during the year and a report of the condition of the Society. They shall fill any vacancies occurring among the officers of the Society. The Council shall, at least one month before the annual meeting, appoint from the active members of the Society three Auditors to examine and certify the accounts of the Treasurer. No officer of the Society shall be eligible as an Auditor. At the first meeting of the Council after the annual meeting, the President shall also appoint from the membership of the Council the following committees, consisting of three members each, to act under the direction of the

Council: Finance, Membership and Publication. The Council may appoint an Executive Committee of three of its members, who shall perform such duties as the Council may determine.

The Finance Committee shall have charge of the financial affairs of the Society, and shall approve in writing all expenditures authorized by the Council.

The Membership Committee shall receive from the Secretary all applications for membership, make rigid inquiry as to the eligibility of candidates, and report to the Council only such as have been approved. In case of disapproval, only the proposers of the applicant shall be notified of such action. The proceedings of this committee shall be private and confidential.

The Publication Committee shall receive and examine all papers for presentation to the Society, and accept such as it may approve. The Committee shall review the papers and discussions which have been presented at the meetings, and shall decide what papers and discussions, or parts of the same, shall be published. It shall publish during each year the transactions of the Society, containing the papers and discussions so approved, and abstracts of the minutes of the Society and of the Council. No members shall publish any papers as having been read before the Society without obtaining the consent of this Committee, and such consent shall not be construed to be an indorsement by the Society of any statements advanced in such papers or publications.

These standing committees shall be guided by such rules and regulations as the Council shall from time to time prescribe.

Sec. 7. The Council shall present at the annual meeting a report, verified by the President and Treasurer or by a majority of the Council, showing the whole amount of real or personal property owned by it, where located and where and how invested, the amount and nature of the property acquired during the year immediately preceding the date of the report, and the manner of the acquisition, the amount applied, appropriated, or expended during the year immediately preceding such date, and the purposes, objects or persons to or for whom such applications, appropriations or expenditures had been made, and the names and places of residence of the persons who have been admitted to membership in the corporation during such year, which report shall be filed with the records of the corporation and an abstract thereof entered in the minutes of the proceedings of the annual meeting. It shall fill any vacancies occurring in the Council and

shall file a certified copy of such appointment with the clerk of the county of New York.

ARTICLE VII.

ELECTION OF OFFICERS.

Section 1. At each annual meeting there shall be elected from among the members by letter ballot as directed in Sections 3, 4 and 5:

A President, to hold office for one year.

Two Vice-Presidents, to hold office for one year.

Eight councilors, each to hold office for one year.

A Treasurer, to hold office for one year.

The term of all elective offices shall begin on the adjournment of the annual meeting of the Society. Officers shall continue in their respective offices until their successors have been elected and have assumed their offices.

A President or Vice-President shall not be eligible for immediate re-election to the same office at the expiration of the term for which he was elected.

Sec. 2. A Nominating Committee, of five members of the Society, not officeholders, shall be elected by ballot at the annual meeting. It shall be the duty of this Nominating Committee to select candidates for the various offices that are to be filled at the next ensuing annual meeting. This Committee shall present to the Secretary, at least ninety days before the day of the annual meeting, the names of candidates for the offices to be filled, first securing the consent of the members selected to stand for the election. Ten or more members of the Society may present to the Secretary, over their signatures, the name of any member of the Society as a candidate for any office, provided they do so within sixty days of the annual meeting, and the Secretary shall add such names to the ballot, provided they are not already included in the list of names presented in the formal report of the Nominating Committee. Such names when presented shall be included on the printed ballot, with a special notation that they are presented by members independent of the Nominating Committee's report.

Sec. 3. Upon receipt of the list of nominations the Secretary shall at once prepare ballots with the names of all candidates and forward them to the members, at least thirty days before the date of the annual meeting.

Sec. 4. Each member entitled to vote shall cancel the names of all candidates for whom he does not wish to vote, and return his vote so that it will reach the Secretary before the date of the annual meeting. Any member may write upon his ballot the name of any member for whom he wishes to vote, if such name is not on the printed ballot. The ballot is to be enclosed in two envelopes, the inner one to be blank and the outer one indorsed by the voter. The votes of members in arrears for more than one year's dues shall not be counted.

Sec. 5. The ballots shall be opened, and the result of the vote declared on the first day of the annual meeting by three tellers appointed by the President. The candidates receiving the highest vote for the several offices shall be declared elected, and shall take office at the last session of the annual meeting.

Sec. 6. Whenever, by resignation or otherwise, there shall be a vacancy in any office, the Council shall have the power to fill such office until the next annual election, and in the event of a tie vote at any election of officers of the Society, the Council, by a majority vote, shall decide the tie.

ARTICLE VIII.

RESIGNATIONS, EXPULSIONS, ETC.

Section 1. Any member whose dues are paid in full may resign at any time. Resignations must be presented in writing, to the Council, who shall act on them at their first meeting following their receipt.

Sec. 2. Any member whose dues shall remain unpaid for one year shall forfeit the privileges of membership, and if he neglect or refuse to pay his dues within thirty days after notification from the Secretary, his name may be stricken from the roll of members by a majority vote of the Council.

Sec. 3. At the end of each fiscal year, the Secretary shall strike from the roll the names of such members as are in arrears for two years' dues to the Society, and shall report the same to the Society at its next meeting.

Sec. 4. Any member may be expelled for conduct on his part likely, in the opinion of the Society, to endanger its welfare, interests, or character; provided, however, that charges have been made to the Council, by a member of the Society in good standing, and that the Council have, after investigation and opportunity for defence, recommended such expulsion.

Sec. 5. Any person ceasing to be a member of the Society, through resignation or otherwise, shall forfeit all right, title and interest in the property of the Society.

ARTICLE IX.

LOCAL CHAPTERS.

Local chapters of the Society may be formed upon application of ten members in any State or Territory or in any political division of any other country, if the organization of such local chapter will, in the judgment of the Council of this Society, advance the Society's interests.

Upon recommendation of the Council, a charter may be granted by the Society to form such local chapter, which shall be operated and conducted under the control and at the pleasure of this Society; such local chapter shall be governed by the Constitution and By-Laws of this Society in so far as they shall not conflict with the laws of such State, Territory or other country, and by such other local By-Laws as may be adopted by the local chapter and approved by the Council of this Society before becoming operative.

The membership of such chapter shall comprise only members of the different grades in good standing in this Society; any member of any local chapter who shall cease to be a member of this Society shall thereby forfeit all right to membership in such local chapter.

Every such local chapter when formed shall be chartered in the name of the State, section of State, County or City, in which the same shall be located.

ARTICLE X.

SOCIETY'S INDORSEMENT.

Recommendation, indorsement or approval shall not be given to or made for any individual, firm, association or corporation, nor for any scientific, literary, mechanical or engineering production. The opinion of the Society, may, however, be expressed on subjects affecting the public welfare, provided that this opinion does not carry with it the promotion of the interests of any individual, firm, association, or corporation, and provided also that it is endorsed by a three-fourths vote of the members present at an annual or semi-annual meeting and approved by the signatures of a majority of the Council present at the meeting.

ARTICLE XI.

AMENDMENTS.

Proposed amendments to this Constitution must be presented in writing at a regular meeting of the Society, signed by at least three members, when if approved by a majority of the members present, the Council shall have copies of the proposed amendment sent to all members, together with the reasons why it is thought desirable by the members presenting it that the changes should be made. The question of its adoption shall be voted upon by a letter ballot in the manner prescribed for election of members.

If two-thirds of the votes cast are in favor of the proposed amendment it shall be adopted.

ARTICLE XII.

BY-LAWS AND RULES.

By-Laws and rules for the further ordering of the affairs of the Society in harmony with this Constitution, may be established and amended by the Council by a two-thirds vote of the members present, written notice of the proposed by-law or rule or amendment having been given at the previous regular meeting of the Council and mailed by the Secretary to each member of the Council at least thirty days in advance of the meeting at which action is to be taken, giving the reason why such by-law, rule and amendment is thought desirable.

ARTICLE XIII.

ORDER OF BUSINESS.

1. Announcement of a quorum.
2. Report of officers—President, Secretary, Treasurer.
3. Report of the Council.
4. Reports of standing and special committees.
5. Unfinished business.
6. Report of tellers of annual election.
7. New business.
8. Reading of papers and discussions.

PARLIAMENTARY RULES.

In all questions arising at any meeting, involving parliamentary rules not provided for in these By-Laws, "Roberts' Rules of Order" shall be the governing authority.

INDEX

PAGE